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**INSECTS INJURIOUS TO THE HOP
IN NEW YORK WITH SPECIAL REFERENCE
TO THE HOP GRUB AND THE HOP REDBUG**

A THESIS

**PRESENTED TO
THE FACULTY OF THE GRADUATE SCHOOL OF CORNELL UNIVERSITY
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY**

**BY
IRA MYRON HAWLEY**

**PUBLISHED AS CORNELL UNIVERSITY AGRICULTURAL
EXPERIMENT STATION MEMIOR 15, NOVEMBER, 1918**

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INSECTS INJURIOUS TO THE HOP IN NEW YORK

WITH SPECIAL REFERENCE TO THE HOP GRUB AND THE HOP REDBUG



INSECTS INJURIOUS TO THE HOP IN NEW YORK¹

WITH SPECIAL REFERENCE TO THE HOP GRUB AND THE HOP REDBUG

I. M. HAWLEY

The investigations herein recorded were begun in the spring of 1913 and continued in 1914 and 1915. The greater part of the time was spent in investigating the hop-vine borer (*Gortyna immanis* Guenée) and methods for controlling it. Two new pests, the hop redbug (*Paracalocoris hawleyi* Knight) and the filamented looper (*Nematocampa limbata* Haworth), were also studied, as well as an old but little-known pest, the hop snout-moth (*Hypona humuli* Harris). Some control experiments against the hop aphid (*Phorodon humuli* Schrank) under New York conditions were conducted, and notes were made on a few pests of lesser importance.

NATURE OF THE HOP PLANT

In order that the relation of these pests to their host plant may be clearly understood, a word should be said regarding the growth and characteristics of the hop.

The growing of hops in the eastern United States is restricted to small sections of New York State, and for this reason the plant is little known. The hop is a perennial plant, the roots living over from year to year and sending up each spring a fresh supply of rapidly growing vines. There are several roots in each hop hill. The hills are from seven to eight feet apart and there are from seven to eight hundred in an acre. The vines must be twined around some sort of support, the commonest form being either poles alone or a series of poles and strings. In some cases two poles and no strings are used, but the commoner method is to have one pole to a hill, with strings running from the middle of each pole to the tops of the ones adjacent to it.

In July and August the main vines send out arms, and on these the hops are borne. The flowers, or burs, are produced the latter part of

¹ Also presented to the Faculty of the Graduate School of Cornell University, June, 1916, as a thesis in partial fulfillment of the requirements for the degree of doctor of philosophy. The work was done under the direction of Professor Glenn W. Herrick. The drawings were made by Miss Anna C. Stryke.

July, and the full-grown hops (fig. 9) may be picked from August 20 to the middle of September, depending on variety, weather conditions, and insect and fungous pests. After the hops are picked they are dried and baled, and are then ready for market.

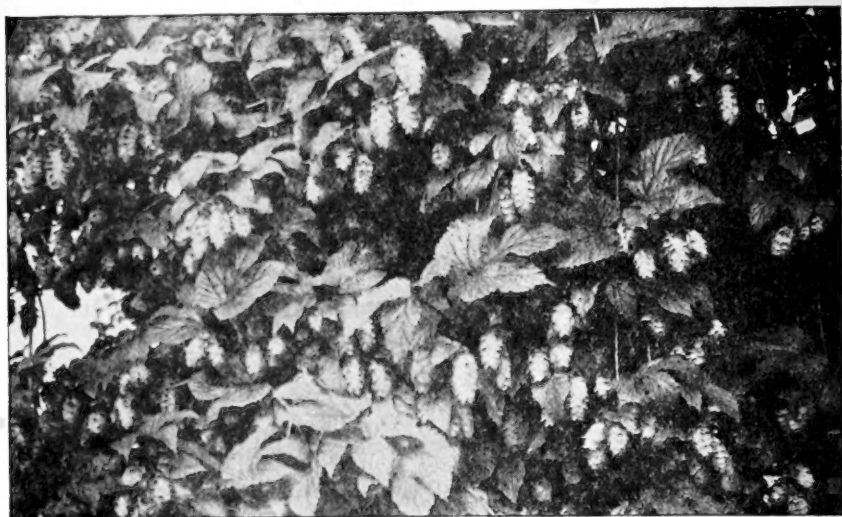


FIG. 9. HOPS AT PICKING TIME

Most hops are used in filling the demands of the breweries. Small oval bodies, known as lupulin granules, are formed at the base of each bract, and these contain resins which give the characteristic taste to the beverages for which hops are used.

THE HOP-VINE BORER, OR HOP GRUB

(*Gortyna immanis* Guenée)

GENERIC HISTORY

- | | |
|--|-----------|
| 1852 — Guenée, A., Histoire naturelle des insectes 5:128 | Hydroecia |
| 1874 — Grote, A. R., Buffalo Soc. Nat. Sci., Bul. 2:18 | Gortyna |
| 1883 — Comstock, J. H., Amer. agr. 42:275 | Apamea |
| 1884 — Smith, J. B., U. S. Div. Ent., Bul. 4, o. s.: 34 | Hydroecia |
| 1885 — Lintner, J. A., New York State Ent., Rept. 2:41 | Gortyna |
| 1893 — Smith, J. B., U. S. Nat. Mus., Bul. 44:175 | Hydroecia |
| 1897 — Howard, L. O., U. S. Div. Ent., Bul. 7:40 | Hydroecia |
| 1902 — Dyar, H. G., List N. A. Lep., p. 175 | Gortyna |
| 1909 — Howard, L. O., The hop, p. 128 | Gortyna |
| 1910 — Hampson, G. F., Cat. Lep. Phal. 9:41 | Hydroecia |
| 1917 — Barnes, W., and McDunnough, J., List Lep. Boreal Amer., p. 69 | Gortyna |

As may be seen from the preceding list, the generic name of *Gortyna immanis* has been changed many times by systematic workers on this group of noctuids. The reason for the changes has been the question of the type of the genus.

COMMON NAMES

The common names applied to *Gortyna immanis* are all based on the work of the larva. Dodge (1882)² gave the insect its first common name, the hop-vine borer; Comstock (1883) retained this name and added that of hop grub; Fletcher (1893 a) applied a third name, the collar-worm of the hop; and a fourth name, the hop-plant borer, was given by Howard (1897). Among hop growers the larvae are known as hop grubs, or more commonly as grubs.

DISTRIBUTION

Gortyna immanis is a native North American insect and has been widely collected in the northern United States and in Canada (Howard, 1897). Smith (1884) gives for its distribution the northern United States from the Atlantic to the Pacific. The insect is especially abundant in the Eastern States and in Canada where hops are grown. In addition captured moths are reported from the States of Illinois, Colorado, and Washington (Howard, 1897).

In spite of the fact that moths have been taken in the State of Washington, no injury to the hop crop of the Pacific coast is reported in entomological literature. One popular article by Daniel Flint (1882) has been quoted as describing injury by the larva of this insect, but the writer of the present paper believes the work described is that of a boring beetle. The "worm" that did the damage does not conform to the characteristics of a lepidopterous larva.

HOSTS

So far as known, *Gortyna immanis* is able to reach maturity only on the hop. Evidence exists, however, supporting the possibility of other hosts. In the spring of 1914 a farmer near Waterville, New York, reported that he had occasionally found the young larvae at work in his corn. This report the writer was unable to verify at that time. Larvae placed on young corn plants in the spring of 1915 flourished until the

² Dates in parenthesis refer to *Bibliography*, page 219, or to *Literature cited*, page 223.

plants were killed. The work was similar to that on the hop during the early stages, when the larva bores inside the stem.

In the spring of 1915 the young larvae were found very commonly breeding in grass in and around hopyards. Their work on grass is very much like the early work on the hop, and is discussed at some length later (page 156). Cages were placed over five of these grass plants on June 7. On August 17 these cages were examined, and no live larvae, pupae, or adults were to be found. It is assumed, therefore, that the larva cannot mature on grass.

FINANCIAL LOSS CAUSED

The loss due to the work of the larva of *Gortyna immanis* varies greatly in different years, and in different yards in any one year. In years when the insects are numerous there may result nearly a total loss to some growers. A hop grower in Bristol, New York, informed the writer that he had seen the damage so great that the hops were not picked. Dodge (1882) estimated the loss due to the insect in New York State in 1879 at \$600,000.

The writer worked in one yard where there were ninety dead vines in one hundred hills, or a computable loss of twenty per cent from the work of the insect. To this must be added the damage in weakened vines. Judging from the hills inspected, this field had not more than twenty-five hills in an acre in which the grubs had not worked. It is probable that a total loss of forty per cent would be a conservative estimate for this yard.

NATURE OF THE INJURY

The injury of *Gortyna immanis* to the hop plant may be classed under four phases, depending on the part of the plant attacked: (1) the work in the head of the hop; (2) the early (inside) work in the vines; (3) the late (outside) work on the vines; (4) the work in the roots.

The work in the head of the hop

Dodge (1882) and later writers on hop insects supposed that the egg of *G. immanis* was laid on the tip of the hop vine early in the spring. It was reported that when the egg hatched, the young larva bored at once into the head, producing a blunted condition known as a muffle

head. As is explained later, this theory of egg laying is incorrect, but it is true that some of the young larvae do find their way into the head of the hop.

Newly hatched larvae of *G. immanis* may crawl long distances and enter any part of the hop plant that is tender enough for their small mandibles, or jaws, to break open. Some of them in their journey reach the head



FIG. 10. HEALTHY AND MUFFLE-HEADED HOP VINES. NATURAL SIZE

The blunted condition of the injured heads on the right should be noted

(Photograph by G. W. Herrick)

of the hop and find a place for easy entrance in the budlike tip. There is no definite place or manner of entrance. Some larvae bore their way into the side of the head, leaving an easily recognizable hole; others enter the tip itself and make their way between the developing leaves; while a few enter the base of the head, or the vine just below the head, causing it to bend to one side. The vines attacked become stockier, and as the

larva feeds on the tender interior tissues, killing the growing point, the head usually takes on a short, thick shape with scraggly leaves, in contrast to the pointed tip with closely folded leaves of a healthy head (fig. 10).

The root of a hop plant sends up fresh vines for a period of several weeks. The writer has noted cases in which, due to late hatching of the

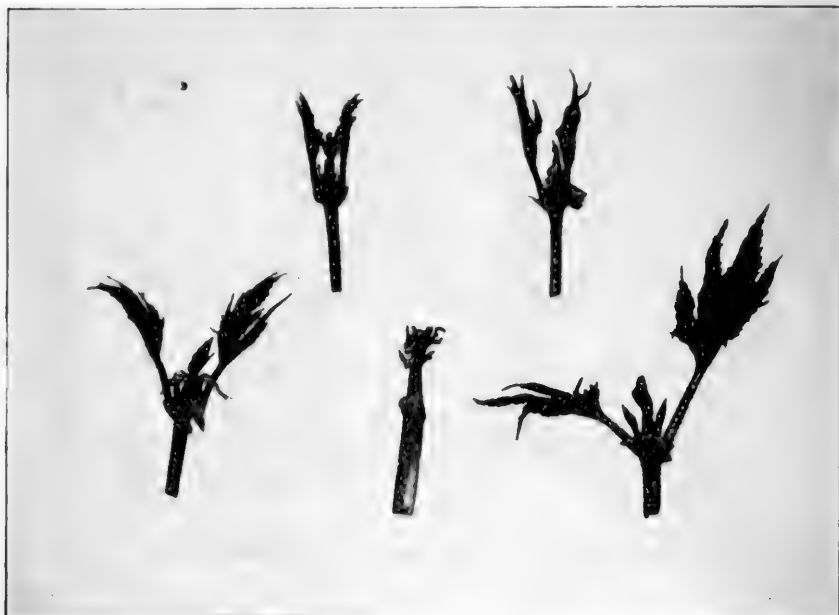


FIG. 11. MUFFLE-HEADED HOP VINES RESULTING FROM THE WORK OF THE HOP-VINE BORER. REDUCED

When the main bud is injured, the leaves and buds just below begin to develop

eggs, the heads of all the young shoots were completely riddled when early vines, then four feet up the poles, were free from injury. In 1915 larvae were found in the hop heads when the yards were first inspected on May 6. At that time the vines of the first lot were less than one foot high. Occasional muffle heads could still be found by the first of June. After working in the tip of the hop for from one to two weeks, most of the larvae drop to the ground and join those working in the vines.

The injury resulting from the work of the larva in the heads is relatively small. The men who tie the hops choose the unaffected vines, and if by accident a muffle-headed vine is used it may be replaced at the next tying. When the head is killed, the two buds at the node just beneath it will grow rapidly (fig. 11), and occasionally one of the arms thus resulting is twined on the pole in place of the main vine.

*The early (inside) work
in the vines*

In contradiction to earlier accounts, the writer has obtained evidence that many of the newly hatched larvae enter the hop vine at once, without first working in the hop heads. Most of the eggs hatch at a time when the vines are short and tender. The young larva enters usually near the surface of the ground — from two to four inches above the bed root. Only a small hole shows on the outside, but at this point the vine breaks on bend-



FIG. 12. VINES CUT OPEN TO SHOW THE WORK OF THE HOP-VINE BORER. $\times 1\frac{1}{2}$

ing and the work of the young larva is found within. A discolored area running up or down the pithy center of the stem marks the course taken. The burrow is filled with waste material behind the little larva as it rapidly eats its way along (fig. 12). The larva grows, and sheds its skin at least twice before it is ready to eat its way from the vine, whose unyielding sides prevent further growth.

The newly hatched larva of *G. immanis* is less than 2 millimeters long, but when ready to leave the vines it has reached a length of from 8 to 18 millimeters. In 1915 most of the larvae were outside the vines by June 9. In the case of one hill examined on that date, one grub was in a hop vine, one was in a blade of grass on the hill, and seven were working on the outside of the vines.

While the larvae work oftener in young, tender shoots, they are sometimes found in the bases of vines that are well up the poles. Occasionally they enter a vine of this kind halfway to the tip, or from two to three feet above the ground. Sometimes a vine is found which has a muffle head and several larvae working in it at different points. All this strengthens the evidence that a larva, after crawling for some distance, enters wherever it can most easily make an opening.

When a larva leaves its burrow in the hop vine, it does one of two things: either it eats its way into a bed root, or it feeds on the outside of the vine between the bed root and the surface of the ground. In very rare cases larvae have been found feeding on runners, or rootstocks, which were not removed by grubbing in the spring.

The late (outside) work on the vines

After leaving the head of the hop or the inside of the vine, the larva usually attacks the outside of the vine and feeds on the sap that flows from the wound. In some cases the vine is eaten completely thru, but oftener it is held together by a small shred and enough nourishment passes thru to keep the foliage from wilting. After feeding in one place the larva often goes to another, above or below the old wound, and repeats its work. Vines thus attacked often send out extra rootlets above the wounded area, and much additional nourishment is received in this way. The sap is able to ascend in vines of this kind, but the return flow of manufactured food material to the roots is cut off. The vine swells above the injured area, due, no doubt, to the deposition of the material being carried downward. The roots, deprived of this food supply, become weaker and succumb more readily to the winter frosts. (Fig. 13.)

The work in the roots

Some of the larvae eat their way into the bed root on hatching, but it is commoner to find partly grown larvae in this position. Larvae

are especially abundant in the roots in unhilled yards, where the roots are close to the surface of the ground. Some grubs make shallow grooves on the outer surface, but many work in the core of the root in all directions. The writer has found twelve larvae in a single root. As the bed root is the part of a plant that lives over the winter and furnishes the growth for the coming season, any injury to it is a serious matter. One result of



FIG. 13. VINES BROKEN OFF FROM THE BED ROOT AS A RESULT OF THE FEEDING OF THE HOP-VINE BORER. SLIGHTLY REDUCED

The enlargement above the place of attack is to be noted

this work of larvae is that an opening is made for soil water to seep in and freeze; also, fungi may enter and start decay. In yards that have been badly infested with grubs, as feeders on either vines or roots, the number of dead hills is always much greater the following spring.

Many grubs are working as external feeders or in the bed root by the end of the first week in June, and by the end of the second week nearly all have finished their work inside the vines. They mature and complete their work in the roots from the middle of July to the middle of August.

THE WORK OF THE YOUNG LARVA IN GRASS

Early in the spring of 1915, larvae of *Gortyna immanis* were found working in grass plants in the hopyards (fig. 14). The work in grass is very similar to the early work in the hop vine. The grub enters, as a rule, close to the ground and bores upward thru the stem. Injured grass may soon be distinguished by the wilting of the central blade. The grub continues its work until about the third stage, and leaves the grass about the time the larvae are leaving the inside of the hop vines.

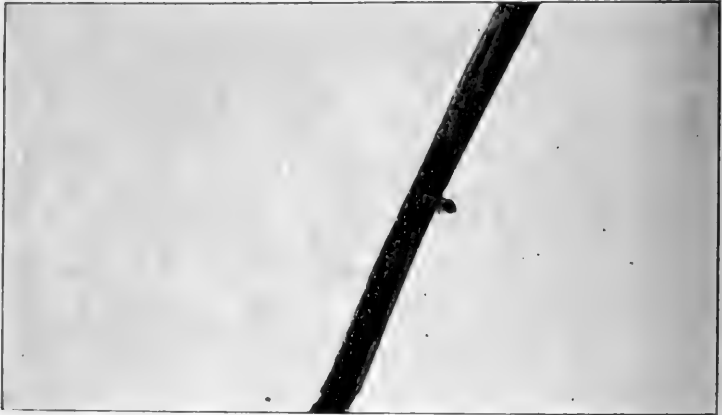


FIG. 14. LARVA OF HOP-VINE BORER IN A GRASS STEM. $\times 3$

Early in the spring grass is common in many hopyards, giving the grubs a good place in which to start their growth (fig. 15). Many larvae are found in the grass along the borders of yards as well as in the yards themselves. It is probable that the moths go to the grass at the sides of the yards for shelter during the day, and lay their eggs there at night. After the eggs hatch, the larvae feed on the grass and later move to the hops. From this it is clear why the edges of the yards are often more seriously injured than the central parts. No larvae were found in grass at a distance from the yards.

In order to see whether other plants could act as hosts, weeds of all kinds were carefully examined, but in no case were larvae found working on them.

TYPES OF YARDS ATTACKED

Poorly-cared-for hopyards having a growth of grass show more injury from *Gortyna immanis* than do those that are well cultivated (figs. 16 and 17). This may be due partly to the less vigorous growth in the former type of yard, but it may be attributed in large measure to the fact that the eggs of the insect are laid on grass and this grass furnishes



FIG. 15. GRASS AROUND A HOP HILL IN MAY
Many larvæ of *Gortyna immanis* work in grass at this time

food for many of the young larvæ before they attack the hop. Yards newly set out, if near an infested yard, are often seriously damaged. One grower was compelled to reset a new yard four and five times in some places before he could get it successfully started.

Old yards in which the grubs have been allowed to work and multiply for a number of years, show the cumulative effect of such work. This is one reason given for taking up old yards and setting out new ones every five to ten years.



FIG. 16. A POORLY KEPT HOPYARD, IN WHICH HAVE BEEN FOUND MANY LARVAE OF THE HOP-VINE BORER

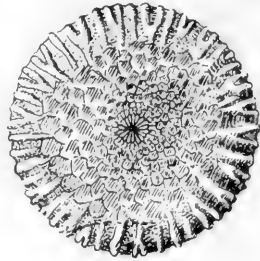


FIG. 17. A WELL-KEPT HOPYARD, IN WHICH ONLY A FEW LARVAE OF THE HOP-VINE BORER HAVE BEEN FOUND AT ONE PLACE

DESCRIPTION OF THE SPECIES

The egg

The egg of *Gortyna immanis* (fig. 18) is 0.65 millimeter in diameter and 0.43 millimeter thick, flattened above and below. The color of the egg when first laid is white or yellow-white, and turns to brownish pink in from one to three days. The egg is faintly marked on the side with about one hundred branching, radiating ridges. The micropyle end has a group of raised polygonal areas, with a rosette formation in the center.

*The larva*

The six stages thru which the larva passes may be described as follows:

First stage.—Length (collected specimen) 3 mm.; head 0.3 mm.; ground color dirty white, with prominent markings of old-rose red; sparse vestiture of setae. Head dark brown or black; antennae, ocelli, and mouth parts light yellow brown. Prothorax, anterior half dirty white, dorsal shield dark brown or black. Mesothorax with four rose-colored patches on lateral aspect of segments, forming a broad, broken, transverse band. Metathorax with markings similar to, but heavier and more irregular than, those of mesothorax. Thoracic legs with coxa white, femur, tibia, and tarsus brown. Abdomen with segments 1 to 8 banded similarly to mesothorax, but bands broader, covering nearly the entire segments; tubercles inconspicuous; spiracles small, dark-bordered, surrounded by a light ring; segment 9 more faintly marked; five pairs of prolegs; venter lighter but with rose tint on abdomen. In grass, hop heads, and vines.



FIG. 18. EGG OF HOP-VINE BORER. $\times 48$

(Only the prominent differences are noted in the descriptions following.)

Second stage.—Length 3.4–6.4 mm.; head 0.65 mm. (average of seven specimens); ground color more prominent, rose-colored markings often less extended and tending to orientation in longitudinal axis, on all segments of thorax and abdomen; setae about one-third as long as diameter of body, and tubercles bearing them more prominent. Head pale yellow-white, clypeus and labrum darker than other parts; ocelli in a dark patch; dark spot on dorsal shield divided by a median light line; spiracles larger, and especially prominent on prothorax. In grass, hop heads, and vines.



FIG. 19. LARVA OF HOP-VINE BORER, FOURTH STAGE. $\times 5$

Third stage.—Length 6.8–8.4 mm.; head 1 mm. (average of eight specimens); ground color more extended and rose patches more regularly arranged; four longitudinal dark lines broken by light spaces; the second (subdorsal) line much narrower than the first and the third; tubercles bearing setae dark brown. In grass and vines.

Fourth stage (fig. 19).—Length 9-15 mm.; head 1.43 mm. (average of eight specimens); ground color still more extended; setae and tubercles large. In vines and in ground.



FIG. 20. LARVA OF HOP-VINE BORER, FULL-GROWN. $\times 1\frac{1}{2}$

Fifth stage.—Length 17-25 mm.; head 2.22 mm. (average of eight specimens); rose markings faint in most specimens, in some entirely wanting. In ground or in roots.

Sixth stage (fig. 20).—Length 27-48 mm.; head 3.91 mm. (average of eight specimens); rose markings entirely lost; color dirty white; fat and unwieldy out of its burrow; tubercles bearing setae standing out prominently, as do brown marks on thoracic and anal shields. In ground.

The pupa

The pupa (fig. 21) is from 20 to 28 millimeters in length and from 7 to 9 millimeters in diameter. It is usually dark brown, but in rare cases is lighter in tint. The cremaster consists of two short spines.

The adult

The adult (fig. 22) is described as follows by Dr. W. T. M. Forbes:

The moth is light brown, with greenish or pinkish reflections in certain lights. The head and thorax are of the same color. The ordinary lines on the fore wing are slightly paler, nearly even, and defined on each side with a darker gray edging; the basal line is present; the t. a. line projects slightly at two points (on veins Sc and Cu); the inner boundary of the t. p., or the outer of the two principal lines, is sharply defined, but the outer is obscure; the line is bent at a right angle just below the costa, from which it starts at a small spot, is slightly bent out near the middle (at vein M_2), and is incurved below; the medial shade is single, dark, angled at the lower side of the cell, and waved below; the st. line (shortly before the margin) is irregular, especially above, and double toward the inner margin; there is a dark terminal



FIG. 21. PUPAE OF HOP-VINE BORER, SHOWING VARIATION IN SIZE. $\times 1\frac{1}{2}$

irregular, especially above, and double toward the inner margin; there is a dark terminal

line; the orbicular spot is erect, the reniform normal. The hind wing is gray, with a somewhat pinkish fringe, dark veins, and an obscure pale and dark t. p. line. Female larger than male. Spread 40 to 51 mm.

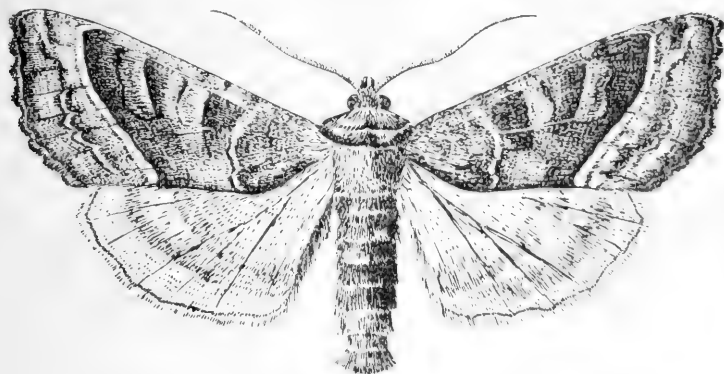


FIG. 22. ADULT FEMALE OF HOP-VINE BORER. $\times 2$

LIFE HISTORY AND HABITS

The egg

The eggs of *Gortyna immanis* were said by Dodge (1882) and later writers to be laid on the tip of the hop vine by overwintering females, but the writer has never seen an egg in this position and has no evidence that they are ever so placed. Under field conditions eggs have been found only on grass, and here they have been found in large numbers.

Prior to 1915 eggs had been found deposited in various places in laboratory and field cages, but no eggs that were known to be those of *G. immanis* had been found under field conditions. In the spring of 1915 a search was made for eggs and young larvae, and on May 10 larvae were found working in grass stems and eggs were found on dead grass blades from the same root. In August of that year cages were built over hop hills on which grass was growing, and full-grown grubs and pupae were placed in them. On the grass in one cage eggs were found on September 1. They were laid both singly and in small groups. Most of the eggs were attached to the outer surface of the grass. On September 6 many eggs were found in the axils of the grass stems, in all cages. Several lots of eggs were found in the field near Sangerfield

on September 7, and from that time on there was little trouble in locating eggs on grass in any yard that had been infested by grubs. During 1915 eggs were found nowhere except on grass plants. (Figs 23 and 24.)

The egg stage lasts about eight months. Eggs are laid from the middle of August to the last of September, and hatch from

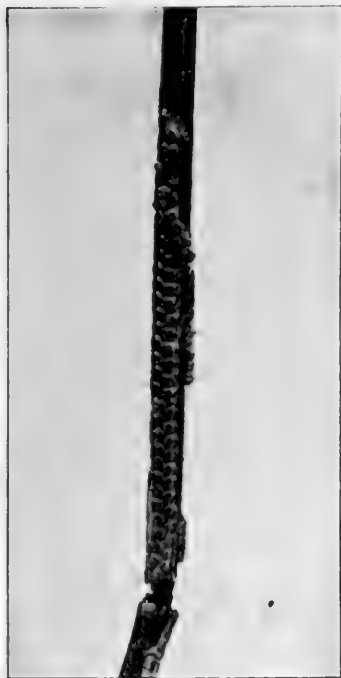


FIG. 23. EGGS OF HOP-VINE BORER
ON A GRASS STEM. $\times 3$

the last week in April to the last of May. A distended female opened in 1914 contained 866 eggs. Others examined in 1915 had 725, 457, and 612 eggs, respectively. No data were gathered on eggs deposited. It is apparent that the number of eggs laid by a single moth may be large. Not all eggs hatch, as many turn black and shrivel soon after being laid. Both shriveled and healthy eggs are found in the same egg mass, and as many as fifty per cent may dry up — due, no doubt, to lack of fertilization.



FIG. 24. EGGS OF HOP-VINE BORER
IN A GRASS STEM WITH THE OUTER
SHEATH REMOVED. $\times 3$

Eggs are laid soon after the moths emerge. The data for three individuals are given in table 1:

TABLE 1. LENGTH OF TIME BETWEEN EMERGENCE AND OVIPOSITION OF THREE MOTHS, 1915

Date of emergence	First eggs laid	Days intervening
August 25.....	September 2	8
August 31.....	September 5	5
August 26.....	September 6	11

The larva

In order to find the number of stages thru which the larva passes in its development, a series of head measurements were taken. Since the larva breeds in vines and beneath the surface of the ground, it is impossible to find the cast skins, and so grubs were preserved in alcohol during the summer of 1914. These were later examined and the transverse measure of the head was taken, as given in table 2:

TABLE 2. HEAD MEASUREMENTS OF LARVAE COLLECTED IN 1914

Stage	Number of specimens	Diameter (in millimeters)		
		Greatest	Least	Average
1st.....	1	0.30	0.30	0.30
2d.....	7	0.68	0.60	0.65
3d.....	8	1.06	0.92	1.00
4th.....	8	1.50	1.37	1.43
5th.....	8	2.46	2.06	2.22
6th.....	8	4.06	3.80	3.91

It is seen from the above data that the larva of *G. immanis* probably passes thru six stages with five molts. The entire length of the larval period is from nine to twelve weeks, since the young larvae hatch from the last of April to the middle of May and pupation occurs during July and the first half of August. No larvae have been successfully bred thru.

Smith (1884) reports that the larva makes a rude cell in which to pupate. Comstock (1883) did not observe this to be true. In rare cases

the writer has found a pupal cell. Whether or not one is formed depends on the texture and the moisture content of the soil at the time of pupation. If the soil is of the consistency of clay and is easily packed a cell may be formed.

The pupa

There is a wide variation in the size of pupae (fig. 21, page 160), as also in the size of adult moths. The writer believed that the small pupae must be those of males and that the large ones would develop into females. Breeding shows that this is not always true, since in some cases females have been reared from pupae of the smaller size.

In 1914 full-grown larvae of *G. immanis* were taken into an unheated field laboratory. The length of the pupal stage under these conditions was found to be as given in table 3:

TABLE 3. LENGTH OF PUPAL STAGE FOR FOUR SPECIMENS UNDER LABORATORY CONDITIONS

Date of pupation	Date of emergence	Days intervening
July 2.....	August 8	37
July 3.....	August 7	35
July 5.....	August 9	35
July 6.....	August 11	36
Average, 36 days.		

From the above data it is seen that the pupal stage lasts a little over one month in the laboratory. Observations by the writer indicate that in the field it varies from four to six weeks. Pupation occurs in the field during July and in the first part of August, and moths emerge during August and September. In 1914 the first pupa was found on July 2, and in 1915 on July 9. In 1914 the first moth emerged on August 10, and in 1915 on August 11. At Waterville the writer found newly transformed moths in field cages as late as the middle of September.

In most cases the full-grown larva leaves the root or the vine and comes close to the surface of the ground before pupation. The pupa is often found some distance down the side of the hill—a foot from the place of larval feeding operations. In rare cases the pupa may be

found near the root and even beneath it. The moths on emerging often leave the pupal skin projecting above the ground. Smith (1884) reported that *G. immanis* usually winters in the pupal stage, but after three years of observation the writer is convinced that all pupae change to adults in the fall. Cages were examined late in September, and all healthy pupae had transformed.

The adult

Adults of *G. immanis*, being colored much like dirt, dead leaves, and hop poles (fig. 25), are seldom seen in the field. It is not uncommon to search for moths in a cage for some time and then find them resting quietly a few inches away. If disturbed they usually flutter their wings and crawl a short distance, but do not fly far if at all.

After depositing eggs the moths die in a very short time, in most cases in about a week. In one case a moth lived for twelve days after completing oviposition. Sweetened solutions were placed in some cages, but did not greatly prolong life. These data were obtained by isolating moths the abdomens of which indicated that they had been laying eggs.



FIG. 25. ADULT HOP-VINE BORER ON HOP POLE. SLIGHTLY REDUCED

SEASONAL HISTORY

The eggs of *Gortyna immanis* are laid in the fall on grass in and around hopyards. The eggs hatch the following spring, in April or May, and the young larvae make their way into grass or hop plants. In grass they eat into the stem near the surface of the ground and feed upward, killing the central blade. They leave the grass at about the time other larvae leave the inside of the hop.

In the hop the young grubs enter the part that is the most readily available and easy to penetrate. This may be the head or any part of the vine. If the larva enters the head, it drops to the ground in about two weeks and helps to increase the large number already working in the vine near the root. About the first of June, when the larva is in the third or the fourth stage, it stops inside work and either feeds on the outside of the vine, nearly or quite severing it, or makes burrows in the root. In July or the first part of August the larva pupates, and the moth emerges the last of August or early in September. The moth deposits eggs, which rest over the winter on grass. The moth dies soon after oviposition.

RELATION OF CLIMATIC AND SOIL CONDITIONS TO SEASONAL HISTORY

Weather conditions have some influence on the life history of *Gortyna immanis*. A late, cold spring retards the development of the larvae somewhat, while warm weather hastens its growth. The winter of 1913-14 was attended with heavy snows which covered the ground in the hop country until late spring, while that of 1914-15 was open and the ground was not covered. A larger number of grubs were present the following spring under the former conditions, in a yard that was under close observation. The snow cover may act as a blanket for the overwintering eggs.

The larva works in any kind of soil. Yards on sandy soil, however, are less affected than those on gravel, clay, or loam.

NATURAL ENEMIES

Predatory enemies

The skunk.—An important destroyer of the larvae, and probably of the pupae, of *Gortyna immanis*, is the skunk. About July 1, when the grubs have reached maturity, numerous holes may be seen in hop hills where skunks have been digging for the fat, juicy larvae. Sometimes the skunk digs the dirt entirely away from the bed root, leaving only about half of the hill standing (fig. 26); at other times it pushes the dirt aside with its nose, making a small, deep hole about three inches in diameter. Not every hill is attacked, and growers say that the animal, hearing the grub feeding, digs in only where it is sure its efforts will be rewarded. The skunk does not always find all the grubs that are present;

the writer has often taken both larvae and pupae from hills in which skunks had recently been working. It is seldom that the vines are injured by the work of the skunk, unless they have been badly eaten by the grub and are hanging by a mere shred.

As a control measure the skunk does much good by reducing the number of larvae and pupae that would complete their development. It does not, however, reduce the injury of the year, for by the time the skunk becomes active the larvae are full-grown and the damage is done.

Predacious beetles.—Several species of carabids feed on the larvae of *G. immanis*, the most daring of these being *Calosoma calidum* Fab. Both the larva and the adult of this species (figs. 27 and 28) are active in attacking the grubs of *G. immanis*. The adults, at least, of other smaller carabids feed on the larvae of *G. immanis* in the younger stages. The following species are known to be predacious: *Harpalus pennsylvanicus* Dej.; *Pterostichus lucublandus* Say; *Pterostichus stygicus* Say; *Amara impuncticollis* Say.

In breeding cages the writer has found dead pupae and adults with holes eaten in the sides of the abdomen. Carabids found in the cages are believed to have done this work. A small carabid collected in the field and placed in a bottle containing several pupae had destroyed one before the laboratory was reached. Masses of eggs partially eaten by a predatory enemy have also been found, and carabids were present in the cage at that time.



FIG. 26. A HOP HILL SHOWING THE HOLE MADE BY A SKUNK IN DIGGING FOR THE LARVAE OF THE HOP-VINE BORER

Parasites

Hymenopterous parasites.—The braconid *Microplitis gortynae* Riley³ is a common parasite on the larva of *Gortyna immanis*. In 1914 the writer



FIG. 27. LARVA OF PREDACIOUS BEETLE. ABOUT NATURAL SIZE
Calosoma calidum

found large numbers of braconid cocoons close to depleted larval skins of the grubs. Eighty cocoons were found with a single skin. These were kept over winter but adults did not emerge. On June 11, 1915, the writer found more of the cocoons when digging grubs. Some adults had emerged and more were just coming out at the time. The braconids were found on top of the ground and crawling all thru the dirt. Some specimens taken to the laboratory and placed with partly grown larvae began laying eggs at once. One

larva, when attacked, whipped its body back and forth, crawled between pieces of dirt, and even turned completely over. In spite of these efforts the parasite still clung firmly until its object was accomplished.

For two weeks after the observation just recorded, braconids were often seen crawling in search of a host in the infested hopyards about Waterville; and later in the summer the cocoons were again found, both in cages and in the field. The larva of the parasite apparently leaves the grub just as the latter is about to pupate. A cocoon of a braconid parasite was found with a dead grub on July 9; a specimen belonging to the genus *Aenopler*³ emerged from this on August 15. Chalcid parasites (*Synaldis* sp.) were bred on August 10 from grubs found on July 9.



FIG. 28. ADULT OF PREDACIOUS BEETLE. SLIGHTLY ENLARGED
Calosoma calidum

³ Determined by A. B. Gahan thru the kindness of Dr. L. O. Howard.

Dipterous parasites.—In the summer of 1914 a tachinid fly, *Frontina frenchii* Will.,⁴ was reared from a full-grown larva. On June 12, 1915, in examining work in vines, a grub skin of *Gortyna immanis* was found with many dipterous larvae crawling in it. Dr. O. A. Johannsen has identified adults bred from these larvae as *Masicera myoidea* Desvoidy, also a tachinid.

Fungous parasites.—In both 1913 and 1914 dead grubs were found which were covered with a fungous growth. In the spring of 1914, F. M. Blodgett succeeded in obtaining from one of these a culture of what appeared to be *Sporotrichum globuliferum*. Later spore suspensions of this fungus were injected into hop hills, but no indication of its inoculating the grubs could be found.

CONTROL

The control of *Gortyna immanis* as practiced in the hopyards of New York State has been almost entirely based on cultural measures. Pinching the tips of the hops that were muffle-headed has been recommended (Dodge, 1882, and later writers), but since few larvae enter the heads this alone is insufficient. Another control method suggested (Dodge, 1882, and others) is to dig the dirt away from the vines and the roots in spring, and leave them in this condition until late in July or early in August, at which time, it is advised, a composite consisting of equal parts of salt, quicklime, and hen manure should be added. It was believed that under these conditions the vines would become so tough that the grubs could not injure them. So far as the writer knows, this method is not practiced at the present time.

In order to test the effect of leaving the roots uncovered, as suggested above, the dirt was removed from ten hills in two yards about June 1. When one yard was examined later, the vines in these ten hills were found to be less developed than the vines in adjacent hills. There were no grubs in this yard. In the other yard grubs were found working in both the vines and the bed roots.

Still another method of control that has been recommended (Dodge, 1882, and other writers) is high hilling. In hilling, men throw dirt around the vines with shovels, covering the hill several inches deep, or plow

⁴ Determined by J. D. Tothill.

close to the hill turning a furrow over it. This is done in June or early July. Some growers claim that hilling draws the grub to the surface and away from its place of feeding on the vine. The writer has not found this to be true. In several yards hilled very high, grubs have been found in quantities in and around the bed root — a foot or more below the surface of the ground.

In highly hilled, well-fertilized yards, the vines often send out rootlets above the injured areas. These supply nourishment to so large an extent that vines nearly severed are often kept alive by this means. Hilling is a good practice for this reason if for no other.

A hop root sends up many more vines than are needed for cultural purposes. When the hops are tied the second time, which is usually about June 1, these extra vines are pulled up or cut off with a knife. This practice is of use in grub control if done in the right manner. At this time many of the grubs are working on the inside of the vines, and if the vines are destroyed the grubs will be killed. It is better to pull the vines out than to cut them off, for, if larvae are working in the vines near the crown, the cut may come above them and they are then free to crawl out and enter vines that have been twined on the poles. The writer has seen many grubs in the stumps of the vines just below the place where they were cut off, and has observed them crawling to adjacent plants. If the vines are pulled, they break off where they join the root. All sprouted vines should be taken from the yards. As grubs work in the late shoots just coming above the ground, these also should be removed at this time. In 1915 most of the grubs were outside the vines by June 9, and the practice of sprouting, to be effective, should in ordinary years be completed before June 1.

An old recommendation (Smith, 1884) is to place wood ashes around vines or scatter them on top of the hills. In 1914 one grower did this about June 13. On examining that yard some time later, the writer found live grubs to be numerous in every hill and dead vines were unusually plentiful.

Sometimes growers resort to digging out the larvae. This has been done in early June, when the work outside the vines was just beginning. The soil is removed from around the hills down to the bed root with a hoe, and the dirt is worked away from between the vines with a pointed stick

in order to remove any grubs that may be feeding deep down near the roots. William Durar, working for George Allen, a grower, at Sangerfield, New York, found that it took twenty-eight hours to go over 267 hills. He averaged, therefore, between 9 and 10 hills an hour, but in addition to digging out the grubs he removed the dead vines and trimmed off the lower arms. If all the time had been spent in digging grubs, it is probable that 12 hills an hour could have been gone over, or 120 hills in a day. At this rate it would take about six days for one man to dig one acre, amounting, at \$2 a day, to \$12 an acre. Another grower reports that grubs can be dug at the rate of 200 hills a day — a cost of \$7.50 an acre. This makes digging a rather expensive process.

In digging grubs, vines that are weakened by feeding may be broken off, and in ordinary practice of this kind the larvae working in the roots would not be found. Men in the hop sections are needed for other work at this season of the year, and it is difficult to get help that can be relied on to do this work in a proper manner. For these reasons, the writer undertook a series of experiments to see whether an effective method of control could not be found at a more reasonable cost to the grower and with less demand on greatly needed labor. The results of these experiments are given in the following pages.

Experiments in 1914

Most of the experiments in 1914 were conducted in the Gallagher yard at Sangerfield, New York. The soil in this yard is a gravelly loam. At the time when most of the materials were applied, the soil was mellow and slightly moist and phosphate had been added at the rate of a few handfuls to each hill. Experiments were conducted in several parts of the yard at once, and counts were made from several hills in each of these plots.

The test of efficiency for most materials is that few live grubs are to be found in the hills when counted. The number of grubs to the hill varies greatly, and so a count of a small number of hills may not give a true average; it may be said, however, that in any case when three or more grubs are left alive, the material may be considered ineffective, as three grubs can destroy an entire hill.

The results of the experiments conducted in 1914 are given in table 4:

TABLE 4. RESULTS OF EXPERIMENTS IN THE GALLAGHER YARD IN 1914

Experi- ment	Material used	Date of appli- cation	Date when grubs were counted	Amount of material applied to each hill	Place of appli- cation	Number of hills counted	Number of grubs to a hill	Remarks
C	Tobacco dust	May 25	June 25	1 handful	In and on hills	10	4.6	
D	Tobacco dust and sulfur	May 25	June 25	1 handful	In and on hills	8	7.0	Equal parts
E	Tobacco dust and lime	May 23	June 26	1 handful	In and on hills	8	8.1	Equal parts
H	Cornell (Lawry) in- sect powder with sulfur	May 24	June 23	1 handful	In hills	10	5.3	Vines burned
I	Oil of tansy and lime	May 23	June 23	1 handful	In hills	10	8.6	1 ounce of oil of tansy mixed with 12½ pounds of lime and 1 pint of wood alcohol.
J	Hellebore and lime	May 24	June 23	1 and 2 handfuls	In hills	10	7.8	1-4
K	Carbolic acid emul- sion, no. 1	May 25	June 25	About 1 pint	On hills	10	4.9	Vines discolored
L	Hellebore decoction	May 24	June 23	About 1 pint	On hills	10	7.9	5 ounces of hellebore, 2½ quarts of water, diluted to 2½ gallons
M	Arsenate of lead and sulfur	May 23	June 26	1 handful	In and on hills	10	7.5	1-4

N.....	Arsenate of lead — vine spray	May 24	June 20	About 1 pint	On hills	10	8.3	5 pounds to 50 gallons of water
S.....	Salt solution (satu- rated)	July 2	July 3	3 quarts	On hills	4	9.0	All vines killed
U.....	Kerosene emulsion (15 per cent)	June 11	June 13	Drench	On hills	5	6.0	
V.....	Black-leaf-40	June 11	June 13	Drench	On hills	10	3.0	1-400, with soap 10-50
W.....	Carbolic acid emul- sion, no. 2	June 11	June 18	Drench	On hills	5	9.6	500 cc. of water, 1000 cc. of acid, 2 ounces of soap diluted to 2½ gallons
X.....	Check	20	8.3	

Experiments with carbon disulfid

Carbon disulfid was tried as a control measure against the larvae in the Gallagher yard. In the first experiment, on July 2, a hole was made in the soil with a sharpened stick and the liquid was poured into it from a bottle. The hole was then filled in. A pint of material was used in eight hills. One hill was opened in fifteen minutes and the remainder

TABLE 5. RESULTS OF EXPERIMENTS WITH CARBON DISULFID IN 1914 — SERIES I
(Time between injection and examination, from 48 to 50 hours. No injury to vines)

Experiment	Distance of application from root (inches)	Number of injections	Quantity used in each injection (cubic centimeters)	Depth of injection (inches)	Number of grubs found	Depth of grubs when found (inches)	Condition of grubs
21.....	3	1	4	6	2	3	Sick
22.....	3	1	8	6	1	3	Dead
23.....	3	2	2	6	2	2	Alive, sick
24.....	3	2	4	6	1	5	Dead
25.....	6	1	2	6	1	3	Dead
26.....	6	1	4	6	2	4	Dead
27.....	6	1	8	6	1	4	Dead
28.....	6	2	2	6	1	6	Dead
29.....	6	2	4	6	1	5	Dead
30.....	6	2	8	6	2	4	Dead
32.....	12	1	4	6	1	3	Alive, active
33.....	12	1	8	6	2	$\left\{ \begin{array}{l} 5 \\ 7 \end{array} \right.$	Dead Nearly dead
34.....	12	2	2	6	1	4	Sick
35.....	12	2	4	6	1	3	Alive

TABLE 6. RESULTS OF EXPERIMENTS WITH CARBON DISULFID IN 1914—SERIES II
(Time between injection and examination, from 48 to 54 hours. No injury to vines)

Experiment	Distance of application from root (inches)	Number of injections	Quantity used in each injection (cubic centimeters)	Depth of injection (inches)	Number of grubs found	Depth of grubs when found (inches)	Condition of grubs
20.....	3	1	2	6	1	3	Dead
21.....	3	1	4	6	1	4	Dead
22.....	3	1	8	6	1	3	Dead
23.....	3	2	2	6	1	5	Dead
24.....	3	2	4	6	1	4	Dead
25							
1.....	6	1	2	6	1	4	Dead
2.....	6	1	2	6	1	3	Dead
3.....	6	1	2	6	1	2	Dead
26							
1.....	6	1	4	6	1	2	Alive, sick
2.....	6	1	4	6	1	4	Dead
3.....	6	1	4	6	1	6	Dead
27							
1.....	6	1	8	6	1	3	Dead
2.....	6	1	8	6	1	2	Dead
3.....	6	1	8	6	1	5	Dead
28							
1.....	6	2	2	6	1	2	Sick
2.....	6	2	2	6	1	7	Dead
29							
1.....	6	2	4	6	1	3	Sick
2.....	6	2	4	6	1	5	Dead
30.....	6	2	8	6	1	4	Dead

in from one and one-half to two hours. Two grubs in the first hill opened recovered from the effects of the vapor, but 57 in the other seven hills were all dead. Many vines were injured. On the following day one pint of the material was applied to twenty hills. From four to seven hours

after the treatment, 118 grubs were found; of these, 106 were dead, 6 were dying, and 6 were alive. The live grubs were on the opposite side of the pole from the injection, or on runners at some distance from the root. The vines in some of the hills were killed.

Conditions at this time were favorable for the effective working of the vapor. The soil was slightly moist and was mellow, and the yard was hilled high. In addition to the grubs, millipedes and beetle larvae were killed. By this time the larvae were full-grown and were becoming scarce. A few were found, however, and these were placed in the center of the hills and doses of different strengths were tried against them. The results are shown in tables 5 and 6 (pages 174 and 175). From these tables it is seen that, under ideal conditions, doses as low as two cubic centimeters to a hill were found effective. Of all the materials tried in 1914, carbon disulfid alone showed signs of success, and therefore the writer decided to test the material more fully in 1915.

In order to test the effect of carbon disulfid on the hops, another series of experiments was conducted. The more important results are given in table 7:

TABLE 7. RESULTS OF INJURY EXPERIMENTS WITH CARBON DISULFID IN 1914

Experiment	Distance of application from root	Number of injections	Quantity used in each injection (cubic centimeters)	Depth of injection (inches)	Resulting injury to plant
1.....	Next to root	1	8	6	2 dead vines
2.....	Next to root	1	4	6	None
3.....	6 inches	1	16	6	None
4.....	6 inches	1	16	6	None
5.....	6 inches	1	16	6	None
6.....	6 inches	1	16	6	None
7.....	6 inches	1	16	6	None
8.....	6 inches	1	16	6	None

Experiments in 1915

Experiments with carbon disulfid

In the spring of 1915, the writer again started experiments with carbon disulfid. These included investigation not only of its use in grub control, but also of the resulting injury to hop plants. The results are given in table 8:

TABLE 8. RESULTS OF CARBON DISULFID INJECTION EXPERIMENTS IN 1915

Experiment	Yard	Quantity used in each injection (cubic centimeters)	Number of injections	Rainfall during experiment (inches)	Date of injection	Date when grubs were counted	Number of hills	Larvae found						Number of hills in check	Number of grubs to a hill in check
								Total number	Number dead	Number sick	Number alive	Per cent alive to a dead	Number alive to a hill		
A.....	Gallagher.....	10	1	0.05	June 9	June 11	8	16	6	2	8	37	1.2	25	1.7
B.....	Gallagher.....	2	1	1.21	June 16	June 18	10	9	3	2	4	33	0.6	25	1.7
C.....															
3.....	Gallagher.....	10	1	1.21	June 16	June 18	10	13	6	5	2	46	0.7	25	1.7
4.....	Gallagher.....	5	2	1.21	June 16	June 18	10	9	6	0	3	67	0.3	25	1.7
2.....	Gallagher.....	4	1	1.21	June 16	June 18	10	20	6	2	12	30	1.4	25	1.7
1.....	Gallagher.....	2	2	1.21	June 16	June 18	10	16	7	6	3	44	0.9	25	1.7
B.....															
1.....	Hicks.....	5	1	1.66	June 21	June 25	10	13	3	1	9	23	1.0	20	4.2
4.....	Hicks.....	15	1	1.66	June 21	June 25	10	19	15	3	1	79	0.4	20	4.2
C.....															
4.....	Hicks.....	5	2	1.66	June 21	June 25	10	73	41	9	23	56	3.2	20	4.2
D.....															
1.....	Hicks.....	5	1	1.66	June 21	June 25	10	21	12	3	6	57	0.9	20	4.2
2.....	Hicks.....	10	1	1.66	June 21	June 25	10	28	17	0	11	61	1.1	20	4.2
B.....															
3.....	Hovey.....	10	1	1.8	June 21	June 28	10	23	12	4	7	52	1.1	20	1.8
C.....															
4.....	Hovey.....	5	2	1.8	June 21	June 28	10	17	4	3	10	23	1.3	20	1.8
B.....															
2.....	Hovey.....	5	1	1.8	June 21	June 28	10	13	3	1	9	23	1.0	20	1.8
1.....	Locke.....	5	1	2.1	June 11	June 22	12	23	0	0	23	0	1.9	6	3.8
2.....	Locke.....	5	1	4.87	June 22	July 7	8	15	4	0	11	27	1.4	8	10.5
3.....	Locke.....	5	2	4.87	June 22	July 7	8	16	1	1	13	6	1.9	8	10.5
1.....	Loue.....	10	1	4.86	June 22	July 2	10	90	18	0	72	20	7.2	5	3.0
2.....	Thayer.....	10	1	3.96	June 23	July 7	10	22	0	0	22	0	2.2	5	3.0
1.....	Campbell.....	15	1	3.21	June 24	July 7	5	4	0	0	4	0	0.8	5	5.0
2.....	Auger.....	5	1	2.73	June 12	June 23	5	56	6	0	50	11	10.0	5	6.4
1.....	King.....	5	1	2.73	June 12	June 23	5	34	0	0	34	0	6.8	5	12.3
2.....	Monkier.....	5	1	3.21	June 24	July 7	5	33	0	0	33	0	6.6	3	6.4
1.....	Walradt.....	5	1	3.21	June 24	July 7	6	16	0	0	16	0	2.7	3	2.5
2.....	Walradt.....	5	1	3.21	June 24	July 7	6	12	0	0	12	0	2.0	3	2.5
.....															
Total Average.....							218	611	170	43	398	27.8	1.8		3.5

In conducting the experiments recorded above, the writer had to contend with a serious handicap in the way of frequent and heavy rains. Much of the soil in the hop region has some clay in its composition. When moist, a soil of this nature is so compact that the vapor meets an impassable barrier. With injections as far as six inches from the vines, it was

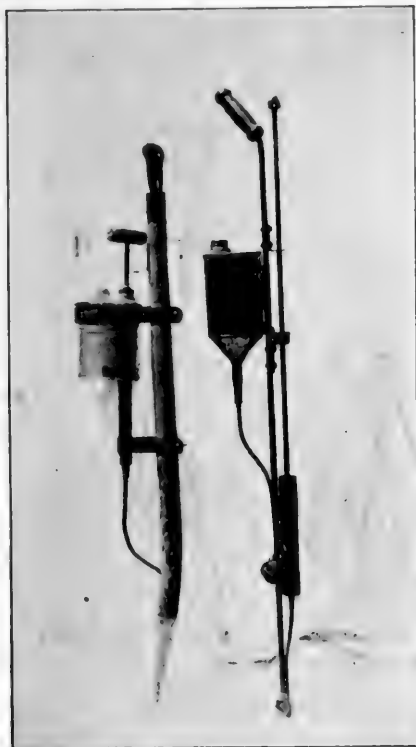


FIG. 29. TWO TYPES OF INJECTORS FOR USE IN TREATING SOIL WITH CARBON DISULFID

found that the carbon disulfid was ineffective. Increasing the dose did not give better results. As a last resort injections near the plants, in most cases directly above the roots, were tried. The result in this case was still ineffective in controlling the grubs and in many cases was disastrous to the plants. In the experiments recorded in table 8, vines were killed as follows: Hicks, B 2, one vine; B 4, four vines; D 2, three vines; Hovey, B 3, many vines; Thayer, fifteen vines; Campbell, nine vines; Moakler, six vines; Walradt, many vines. The depth of injections was from two to three inches.

With the object of finding a way to place the liquid rapidly and uniformly in the soil, the writer, with the aid of F. M. Blodgett, devised an injector (fig. 29). So far as the writer knows, nothing of the kind is at present on the market in this country.

From the data in table 8, it is seen that the counts of living and of dead grubs show only 27.8 per cent control for the season's work. Sick grubs in the counts are considered as live ones because, due to the length of time and the weakening of the vapor density between injection and counting, sick ones would no doubt have recovered. The average number of live grubs per hill is given to show the comparative averages for check and for treated plots.

Taken as a whole, the results are very unsatisfactory. The writer believes, however, that in some soil and under ideal moisture conditions good results may be obtained. Since these conditions cannot be controlled the use of carbon disulfid is of doubtful importance.

Injury to hop vines from carbon disulfid.—Carbon disulfid will kill a hop vine or root whenever it comes into actual contact with it. The writer has noticed that vines which are badly eaten by the grubs are killed oftener than those that are not. A series of experiments in moist sandy soil showed that 15 cubic centimeters of carbon disulfid placed close to the vines had no serious effect. The sandy soil, being porous, no doubt allowed a better spread of the vapor. The results of an experiment in the Gallagher yard, where the soil is a gravelly loam, are given in table 9:

TABLE 9. RESULTS OF INJURY EXPERIMENTS WITH CARBON DISULFID IN 1915
(Injections were made on June 16; plants were examined on July 10)

Experiment	Quantity used in each injection (cubic cen- timeters)	Number of injections	Distance of application from root (inches)	Number of live vines	Number of dead vines
1 a.....	16	1	4	2	2
1 b.....	8	2	4	4	0
2 a.....	24	1	4	2	2
2 b.....	12	2	4	2	2
3 a.....	32	1	4	0	4
3 b.....	16	2	4	0	4
4 b.....	21	2	4	0	4
5 b.....	24	2	4	1	3

Experiments with poison bait

In spite of poor results obtained in 1914 from the use of poison bait it seemed possible that it might be applied successfully, and on June 11, 1915, a plot in the Gallagher yard was treated with a bait composed of $2\frac{1}{2}$ pounds of bran, $\frac{1}{2}$ pound of white arsenic, $1\frac{1}{2}$ pint of molasses, and the juice of an orange. This is stronger in arsenic than the mixture used against the army worm.

A rainfall of 0.26 inch occurred soon after this experiment was started, and therefore another plot was treated on June 12 with a mixture of the same strength. The material was placed close around the vines, the dirt

being removed to make this possible. On June 14 the following counts were made: in the plot treated on June 11 there were 30 grubs in ten hills, of which 28 were alive and 2 were dead; in the plot treated on June 12 there were 27 grubs in ten hills, all of which were alive; the check showed 29 grubs in ten hills. Grubs placed in a jelly glass with poison bait on June 12 were sick on June 13 and died on June 14. It is probable, therefore, that these larvae will feed on poison bait when the preferred hop vines are not present, but that they will not touch it under field conditions. A bait applied in May to catch the hatching larvae might prove effective.

Experiments with para-dichlorobenzene

Para-dichlorobenzene has been successfully used against various pests of stored grains. Duckett (1915) described its use, and from his account the following data are taken: Para-dichlorobenzene is a colorless, crystalline substance with a boiling point of 341.6° F. It volatilizes readily as a colorless vapor with an ether-like odor. This vapor, which is five times as heavy as air and twice as heavy as carbon disulfid vapor, is harmless to human beings but is a specific poison for insects under many conditions, killing by action on the nervous system. The insect begins quivering and finally turns on its back and, still quivering, dies. The cost is 15 cents a pound in barrel lots, and 35 cents a pound in small quantities.

It may be added that in 1915, due to the war, the price of para-dichlorobenzene rose to 35 cents a pound in large lots and 60 cents a pound in small quantities, and it was soon impossible to obtain it at these prices. However, it is now manufactured in this country and may be obtained at a much lower cost. So far as published results indicate, its use is recommended only in the case of certain stored-grain and household insects.

The writer tested this material against the larva of *Gortyna immanis*. The results of three experiments are given in table 10.

In all cases the characteristic odor was noticeable and crystals could still be found in the hills when they were examined. Of the seven live grubs in the Hicks yard, two were near the surface and three were on runners at some distance to one side. Sick grubs were counted as dead, since the material was still active and would doubtless have killed them if left undisturbed. Dead *Laehnosteria* larvae and carabids also were found, but millipedes were usually able to escape the action of the vapor.

Dead grubs are soft and black, and sick grubs are often slightly discolored. The vapor would no doubt spread more rapidly in normal years, free from the frequent heavy rains, and it will be interesting to see the effect of the material on the grubs under ordinary conditions. No plant injury was noticed during the experiments, but 56 grams of para-dichlorobenzene placed around one hill killed the plant in eleven days.

TABLE 10. RESULTS OF EXPERIMENTS WITH PARA-DICHLOROBENZENE
(Ten hills counted in each yard)

Yard	Date when experiment was started	Date when experiment was closed	Amount of material used	Larvae found				Per cent of control
				Total number	Number dead	Number sick	Number alive	
Gallagher.....	June 18	July 10	A few crystals	14	12	1	1	92.8
Hicks.....	June 21	July 10	A few crystals	39	28	4	7	82.0
Hovey.....	June 21	June 28	A few crystals	37	32	3	2	94.6

The ideal insecticide for grub control would be a material with long-lasting effect, which could be easily placed in the soil when early hilling is practiced. Para-dichlorobenzene may act successfully in this way. Its insolubility in water and its activity in the soil over such long periods of time would tend to indicate this. More study should be given to this side of the work.

Recommendations

The following practices are recommended for control of the hop-vine borer:

1. Remove all extra vines before June 1. Pull out the extra vines and remove them some distance from the yard.
2. Hill the hops, so as to give the extra rootlets an opportunity to grow.
3. Practice clean cultivation; in other words, remove the grass from the yard.
4. Keep a plowed border several yards wide around the field.
5. For an insecticide, experiment with para-dichlorobenzene, using a few crystals in each hill and covering with about two inches of dirt. This should be applied about the third week of May.

THE HOP REDBUG

(Paracalocoris hawleyi Knight)

During the past few years hop plants in the yards about Waterville, New York, especially in those in the vicinity of Sangerfield, have shown



FIG. 30. WORK OF THE HOP REDBUG ON HOP VINE AND LEAVES. REDUCED

conspicuous injury of the foliage by perforations of the leaves, and also a stunting and deformation of the stems. In June, 1913, the vines in several yards at Sangerfield were notably injured in this manner. Careful examination of the affected plants disclosed the presence of large numbers of red nymphs with white markings. When these yards were examined early in July the nymphs were feeding on the vines and sap was flowing from the wounds made by them. A few adults were taken at that time, which later were found to belong to the family Miridae. Because of their striking color the writer has called them the hop redbug. Each year since 1913 the insect has increased greatly in numbers and has caused more and more injury. It may now be found in yards ten miles from Sangerfield, but it does

not appear to have reached the Cooperstown district thirty miles distant.

The writer submitted a large series of specimens for examination to H. H. Knight, who reported them as representing a new species which he described as *Paracalocoris hawleyi*. Later the determination was confirmed by W. L. McAtee, who in addition described several varieties of the species.

NATURE OF THE INJURY

The injury caused by the hop redbug may be recognized by the deformed and stunted vines and the irregular holes in the leaves (figs. 30 and 31). The earliest injury is made evident by many light spots in the still folded leaves, and on close examination it is found that the epidermis is broken on the underside. Later, as growth of the leaf continues, a dead area is

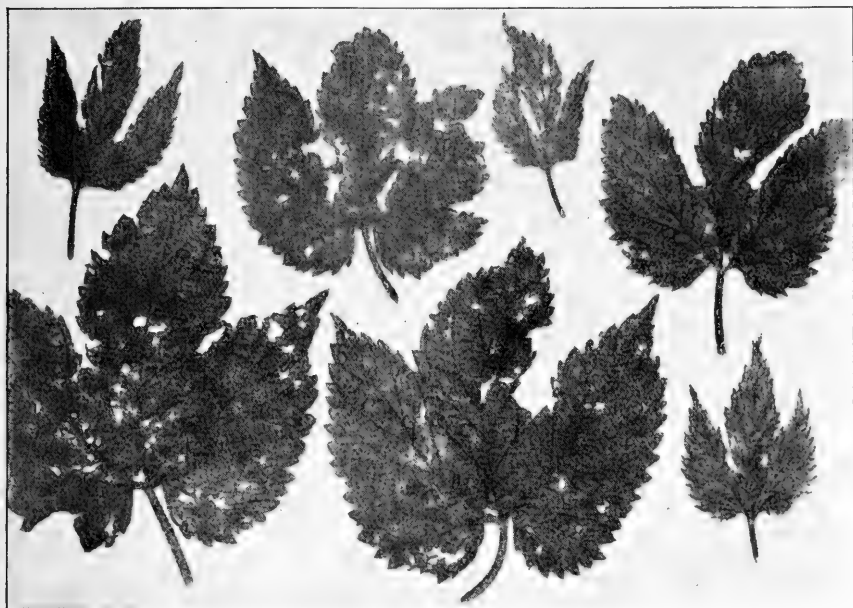


FIG. 31. LEAVES SHOWING RESULTS OF FEEDING OF THE HOP REDBUG

produced, and when this drops out an irregular hole results. The early work is found about the middle of June, and by the middle of July the leaves may be completely riddled.

In later stages the nymphs may feed on the vines, causing a flow of sap from the punctures. As the vine grows it often becomes stunted on the side attacked, and by the continuance of its growth on the opposite side a sharp bend is formed. A plant is often weakened so that its clinging power is lost; the main stems tend to hang down, and often all the vines

of the hill slip down around the base of the pole (fig. 32). The older nymphs may feed also on the burs and the hop heads, but serious injury to these parts could not be detected by the writer. Pole yards are attacked worse than are string yards, and in string yards the vines on the poles show more injury than do those on the strings.



FIG. 32. A HOP HILL SO WEAKENED BY THE WORK OF THE HOP REDBUG THAT THE VINES HAVE SLIPPED DOWN THE POLE

The work of the hop redbug is similar to that described by Theobald (1895) for a related species, *Calocoris fulvomaculatus* Deg., which has caused some injury to the hop in England.

DESCRIPTION OF THE SPECIES

The egg

The egg of the hop redbug (fig. 33) is 1.6 millimeters long, 0.4 millimeter wide, and 0.2 millimeter thick. The color is dirty white. The egg is curved, with two prominent, pure white, incurving hooks on the micropyle end; one hook is pointed and the other is blunt at the tip. The surface of the egg is smooth and glossy.



FIG. 33. EGG OF HOP REDBUG. $\times 24$

The nymph

The five nymphal stages may be described as follows:

First stage (fig. 34).—Length 1.3 mm. (average of ten specimens); general color light tomato red; a median variable light line extending from near the cephalic end of the head to near the posterior end of the second abdominal segment, faint in some specimens but in others distinctly white, bordered laterally on the thorax by clay-colored patches. Antennae with the basal segment slightly clubbed, tomato red, and sparsely clothed with hairs; the second segment sparsely hairy, white (2/5) and red (3/5); the third segment sparsely hairy, white ($\frac{1}{2}$) and red ($\frac{1}{2}$); the fourth segment densely hairy, clay color with a small white spot at base. Coxa of leg white, trochanter white, femur red, tibia with three red and three white bands of varying breadth, tarsus white with dark tip, claw dark. Each abdominal segment bearing a row of dark setae; head and thorax with irregularly arranged setae. Beak white with dark tip. Venter clay color. In a few cases the median line wanting, as well as all white bands,

the insect being red with the exception of the fourth antennal segment. (The description is for the most typical specimens.)

Second stage (fig. 35).—Length 1.9 mm.; general color slightly darker; median line broader and more distinct; clay-colored border patches indistinct; bands on antennae and legs more prominent; white spots beginning to appear around setae on abdominal segments; basal



FIG. 34. FIRST-STAGE NYMPH OF HOP REDBUG. \times ABOUT 20

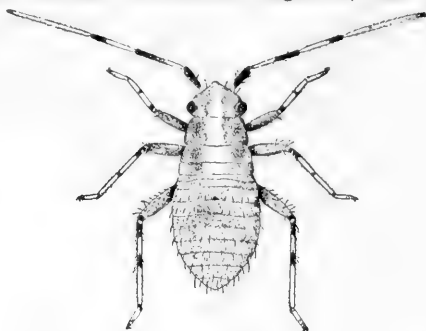


FIG. 35. SECOND-STAGE NYMPH OF HOP REDBUG. \times NEARLY 15

antennal segment a darker red and much more hairy; terminal segments lighter except at tip. Aberrant specimens showing no median line, no white bands, faint bands on antennae and legs, or faint bands on antennae and none on legs.

Third stage (fig. 36).—Length 2.5 mm.; general color same as that of preceding stage; red bands on antennae and legs much darker than body; wing pads beginning to show;

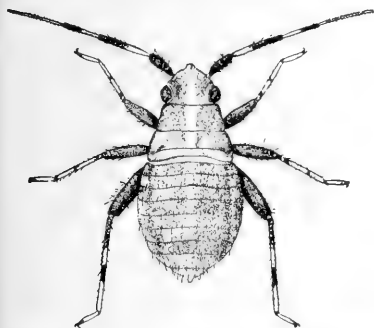


FIG. 36. THIRD-STAGE NYMPH OF HOP REDBUG. \times NEARLY 11

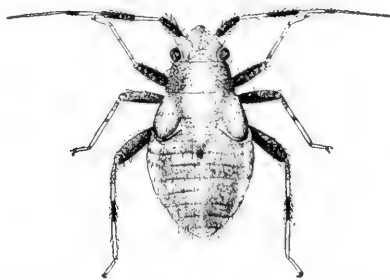


FIG. 37. FOURTH-STAGE NYMPH OF HOP REDBUG. \times 9

white spots around setae more distinct. Setae longer and coarser. Some aberrant specimens as in second stage.

Fourth stage (fig. 37).—Length 3.1 mm.; general color as in third stage; wing pads brownish and reaching nearly to third abdominal segment; antennal segments thicker in red areas than in white; dusky spot showing around gland between third and fourth abdominal segments. Aberrant specimens as in preceding stages.

Fifth stage (fig. 38).—Length 4 mm.; a wide variation in color, some specimens being light red with almost transparent wing pads, others dark red with wing pads and dark spots of legs sepia; wing pads reaching almost midway between fourth and fifth abdominal segments; dusky spot around gland more prominent; in some cases two dark spots on pronotum; white spots around setae very distinct. A wide variation in markings, as in earlier stages.



FIG. 38. FIFTH-STAGE NYMPH OF HOP REDBUG. $\times 7$

LIFE HISTORY AND HABITS

The egg

The eggs of *Paracalocoris hawleyi* are inserted singly, and in groups of two, three, or four, in the bark or the wood of hop poles, to which they are attached by a secretion. In cedar bark the eggs are placed in a slit in the bark transverse to the grain, and can best be seen when the bark is torn lengthwise (fig. 39). When found in this way, the otherwise inconspicuous white cap may be located on the outside. Only one egg has been found in the hard wood of a pole, and this was in a crack just deep enough to hold it. Since nymphs are equally common in the spring on the cedar bark poles and on the wooden poles, eggs must be laid here in large numbers. The egg stage lasts from nine to nine and one-half months.



FIG. 39. EGGS OF HOP REDBUG INSERTED IN BARK OF CEDAR HOP POLE. $\times 9$

The nymph

The nymphs are active, and when disturbed they crawl rapidly among the leaves and vines and into the cracks of the hop poles. At rest they

may usually be found on the undersides of the tenderest leaves, there being often from five to ten nymphs on a leaf and one hundred or more to a hill. When jarred they drop straight down to a lower leaf, to which they often adhere by everting the end of the alimentary canal. They prefer the tender leaves and vines, and therefore in August are more numerous near the tops of the poles.

The data on four specimens bred in the year 1915 are given in table 11:

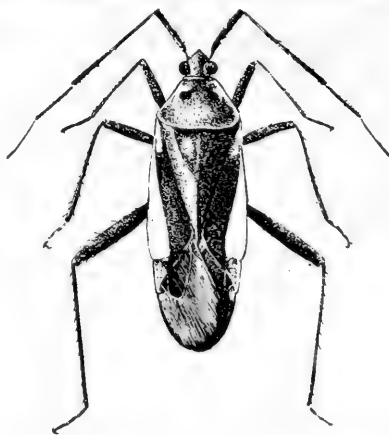
TABLE 11. DATES OF TRANSFORMATION AND LENGTH OF STAGES, 1915

Specimen	Date when egg was taken	Date of hatching	Date of beginning of nymphal stages after first				Date when adult stage began	Number of days from egg to adult
			Second	Third	Fourth	Fifth		
1.....	May 21	June 13	June 19	June 21	June 30	July 8	July 14	31
2.....	May 21	June 13	June 19	June 21	June 30	July 6	July 13	30
3.....	May 6	June 15	June 20	June 24	June 30	July 6	July 13	28
4.....	May 6	June 10	June 15	June 22	June 30	July 7	July 12	32
Average, 30.2 days.								

The specimens were bred in petri dishes in a well-ventilated, unheated field laboratory. Pieces of bark containing eggs were placed in the dishes. These were examined, and after hatching fresh food was added, each day.

The adult

The adult when disturbed drops a short distance and then flies gradually downward in a zigzag course. Adults may be found at rest on the vines, on the poles, and on the upper and under surfaces of the leaves. Technical descriptions of the species and of four varieties have been published by McAtee (1916), who examined material sent him by H. H. Knight. Of these four varieties, *Paracalocoris hawleyi* var. *hawleyi* and *P. hawleyi* var. *ancora* (figs. 40 and 41, respectively), are the common forms on the hop. The former has a pale lateral

FIG. 40. ADULT OF ONE VARIETY (*hawleyi*) OF HOP REDBUG. $\times 6\frac{1}{2}$

stripe on the corium, which is not present on the latter. The latter variety is much more numerous than the former.

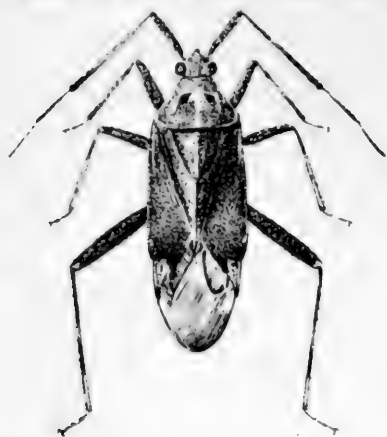


FIG. 41. ADULT OF ANOTHER VARIETY (*ancora*) OF HOP REDBUG. $\times 6\frac{1}{2}$

SEASONAL HISTORY

Overwintering eggs of *Paracalocoris hawleyi* are laid in hop poles from the middle of August until September, as determined by dissected adults. These hatch the following year from June 1 up to nearly the first of July. The nymphal period lasts for about thirty days, adults beginning to appear about the first of July. Nearly all are winged by the first of August. Adults may often be found in September but there is no evidence that these survive the winter.

NATURAL ENEMIES

The pentatomid *Apateticus maculiventris* Say is predacious in both the nymphal and the adult form on the immature stages of the hop redbug. Eggs and nymphs of this species are common in hopyards in July and August.

One of the Nabidae, *Reduviolus subcoloptratus* Kirby, which is present on many plants near the hopyards, has been found feeding on nymphs of the hop redbug.

A predacious red mite, *Trombidium* sp., has been observed on several nymphs.

PREDACIOUS HABIT OF THE HOP REDBUG

Adults of *Paracalocoris hawleyi* have been found feeding on nymphs of their own kind. Nymphs have been found also feeding on the pupae of *Nematocampa limbata* Haworth (Geometridae), the larvae of *Lycia cognataria* Guenée (Geometridae), the larvae of *Hypena humuli* Harris (Noctuidae), and the pupae of *Malacosoma americana* Fab. (Lasiocampidae).

CONTROL

In 1915 it was decided to test a tobacco extract spray as a control measure against the hop redbug. To this end nicotine sulfate, 1 pint to 100 gallons of water with 6 pounds of soap added, was applied on July 17. The material apparently killed the bugs at once. However, as 56 live nymphs were found on six sprayed hills, another spray was applied on July 19. This time Black-leaf-40, 1 pint to 100 gallons of water with 4 pounds of soap, was used. On July 20 six hills had 16 dead and 11 live nymphs present, but on July 21 no dead nymphs could be found. This is due to the fact that after the spray material dries, the nymphs drop off. The following experiment shows that whenever nymphs are reached they are killed. On July 19, when the field experiments in spraying were made, 40 sprayed specimens were placed in a laboratory cage, none of which revived. Thirty specimens sprayed with an atomizer were all killed by the same solution as was used in the field.

Since nicotine sulfate, $\frac{3}{8}$ pint to 100 gallons of water with 4 pounds of soap, will control the hop aphid (*Phorodon humuli* Schrank), the writer tried it to ascertain its effect on the hop redbug. Leaves with redbugs from vines sprayed in the field were taken into the laboratory; of 15 specimens, 6 were alive on the following day. Of 30 redbugs sprayed in the laboratory, 7 were alive twenty-four hours later. Bugs that became attached to the glass dish by means of the solution were invariably killed; those not attached often recovered. To prevent sticking, filter paper was placed in the bottom of the dish and the bugs were sprayed with an atomizer. Of 10 treated in this way, 6 were killed. It is evident that this strength is insufficient for the control of the redbug.

To be successful, spraying should be done about the third week in June, before the vines have produced large arms. Most of the nymphs will have hatched and can be reached easily at this time. Later, when the vines have become dense and many have slipped down the poles, it is impossible to reach all the bugs hidden among the mass of leaves. Poles as well as vines should be drenched, since many nymphs take refuge in the cracks and under projecting bark. Because of the agility of the bugs, it is wise to spray a hill from opposite sides at the same time when possible. Winged forms fly before they can be reached by a spray.

THE HOP SNOOT-MOTH
(*Hyppena humuli* Harris)

The larva of the hop snout-moth was recorded in 1841 as a leaf-eating pest. It is widely distributed, occurring in most parts of the United States and southern Canada. So far as known it feeds only on the hop, and thus its distribution tends to follow that of its host (Howard, 1897). It has not been reported as a serious pest on the Pacific coast. As a rule the injury that it causes is not great, but at intervals the larvae of the second brood occur in such large numbers as to strip the hop vines of their leaves. The writer has found occasional hills in this condition but there has not been a general outbreak of the insect in the past five years.

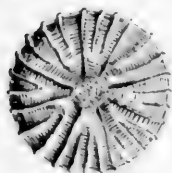


FIG. 42. EGG OF
HOP SNOOT-MOTH.
× 40

The egg of *Hyppena humuli* (fig. 42) is from 0.5 to 0.6 millimeter in diameter. In color it is pale yellow-white. The form is circular, slightly dome-shaped, flattened below. The surface is vertically ridged and grooved. There are apparently eight primary ribs converging at the micropyle end, with two or three secondary ribs between each pair of primaries. The micropyle is slightly flattened and irregularly reticulated.

DESCRIPTION

The egg

The larva

The larva (fig. 43) is from 20 to 25 millimeters in length. The color is pale green, marked by a median longitudinal dark line and a prominent dorso-lateral white line with a fainter white line in the region of the spiracle. The head as well as the body bears prominent black tubercles. There are four pairs of prolegs including the anal prolegs.

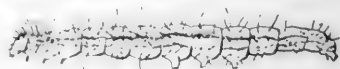


FIG. 43. FULL-GROWN LARVA OF
HOP SNOOT-MOTH. SLIGHTLY
ENLARGED

The pupa

The pupa is from 11.5 to 12.5 millimeters in length and 3.5 millimeters in greatest diameter. The body is dark brown, glossy, and faintly clothed with hairs. The cremaster consists of two large, outwardly pointing

hooks at the tip, with two smaller ones on each side. The ventral side bears a fourth pair of hooks.

The adult

The adult (fig. 44) is described as follows by Dr. W. T. M. Forbes:

The fore wing of the female is light wood brown, with a smoky gray trapezoidal patch resting on the inner margin rather before the middle; the base of the fore wing is more or



FIG. 44. ADULT FEMALE OF HOP SNOOT-MOTH ON
A HOP LEAF. $\times 2$

less darkened, and there is a dark shade on the outer margin, below a blackish streak which runs down obliquely from the apex; four small black tufts outline the trapezoidal patch; the usual noctuid markings are present, but are obscure, except for a row of black dots before the outer margin, representing the st. line. The hind wings and the body are similarly colored, without distinct markings. The palpi extend straight forward and are as long as the thorax, and with a tuft of hair on the face they give the appearance of a beak; the terminal joint is short and upturned. The inner margin of the fore wing is nearly straight

(unlike the clover *Hypena*, *Plathypena scabra*). The male is similar, but the fore wings are even dull gray, with all the markings obscure. The male is slightly larger than the female. Spread 25 to 30 mm.

LIFE HISTORY AND HABITS

The egg

The eggs of the first brood of *Hypena humuli* are deposited among the hairs on the underside of the hop leaf (fig. 45) during May, at which time



FIG. 45. EGG OF HOP SNOUT-MOTH ON LEAF. $\times 2\frac{1}{2}$

the hops are only a few feet above ground. Eight eggs have been found on one folded leaf. These eggs, which are laid by overwintering females, may not hatch for three weeks; the exact length of the egg stage is not known. About two days before hatching, the eggs turn dark and the young larvae may be seen within. Eggs have been found in the field from May 6 to June 7.

The eggs of the second brood also are deposited on the leaves. In some cases they are laid on the older leaves near the ground, but they

may be found on tender leaves near the top of the pole. Eggs of the second brood have been found from July 28 to August 11.

The larva

The larva is a semi-looper, and when disturbed often throws its head in the air like a geometer. At rest it may be found stretched at full length on the underside of a leaf. Its color so protects it that it may be easily overlooked (fig. 46). When disturbed it moves its body



FIG. 46. FULL-GROWN LARVA OF HOP SNOOT-MOTH ON LEAF. NATURAL SIZE

back and forth with a wriggling motion, and drops by means of a thread. It may sometimes be found suspended in the air by this means. A newly-hatched larva (fig. 47) rarely eats thru a leaf in feeding, but when a few days older it eats out a clean-cut hole either on the margin or in the central part of the leaf. Full-grown larvae of the first brood have been taken from June 17 to July 21, and those of the second brood from August 15 to September 6.

In these experiments breeding was carried on in a field laboratory. In 1914 leaves were placed in jars of water and covered with a lamp

chimney. In 1915 larvae were kept in petri dishes to which a fresh leaf was added each day. The breeding records of 1914 and 1915 are given in tables 12 and 13.



FIG. 47. YOUNG LARVA OF HOP SNOOT-MOTH ON LEAF, WITH RECENTLY SHED SKIN. \times ABOUT 5

TABLE 12. DATES OF TRANSFORMATION AND LENGTH OF STAGES OF FIRST BROOD, 1914

Specimen	Date when egg was taken	Date of hatching	Dates of molts	Date when pupal stage began	Date when adult stage began	Number of days from egg to adult
1.....	May 26	May 28	June 1, 6, 11	June 16	July 1	34
2.....	May 26	May 28	June 1, 5, 11	June 23	July 5	38
3.....	May 26	May 28	June 1, 5, 12	June 23	July 6	39
4.....	May 26	May 28	June 1, 5, 11	June 24	July 7	40
5.....	May 26	May 28	June 2, 6, 14	June 23	July 6	39
6.....	May 26	May 28	June 2, 6, 14	June 25	July 7	40

Average — Larval stage, 25.3 days; pupal stage, 13 days; egg to adult, 38.3 days.

TABLE 13. DATES OF TRANSFORMATION AND LENGTH OF STAGES OF FIRST BROOD, 1915

Specimen	Date when egg was taken	Date of hatching	Dates of molts	Date when cocoon was spun	Date when pupal stage began	Date when adult stage began	Number of days from egg to adult
1.....	May 6	May 18	.....	June 18	June 21	July 8	51
2.....	May 6	May 21	.....	June 21	June 23	July 8	48
3.....	May 28	June 7	.....	.....	July 5	July 17	40
4.....	May 28	June 8	.....	July 7	July 8	July 21	43
5.....	May 21	June 13	June 17, 26, 30	July 7	July 9	July 21	38
6.....	June 7	June 13	June 17, 23, 30	July 11	July 12	July 26	43

Average — Larval stage, 30 days; pupal stage, 13.8 days; egg to adult, 43.8 days.

The pupa

There has been much disagreement as to the manner and place of pupation of the hop snout-moth (Howard, 1897), arising from the large variety of conditions under which the process may occur. The writer has found naked pupae on the surface of the soil or just beneath the upper layer of dirt, or attached to leaves and hop poles by a few strands of silk (fig. 48). Inclosed pupae have been found fastened in cocoons in a single rolled leaf and between two leaves. They have been found also on hop poles, on dead vines, and in dirt. The cocoon may be frail or heavy. A cocoon found in the ground was covered with small particles of dirt. Pupae of the second brood are usually found naked and in the ground. Pupae of the first brood have been found between June 16 and July 26, and those of the second brood between August 19 and September 16.

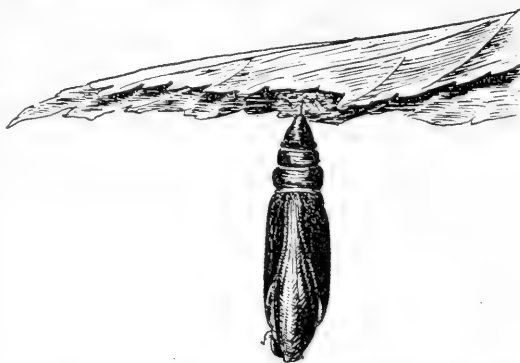


FIG. 48. PUPA SKIN OF HOP SNOOT-MOTH ATTACHED TO LEAF. $\times 2\frac{1}{2}$

The adult

The adult of *Hypena humuli* has been taken in the spring and late in the fall. All pupae under observation have transformed to moths in September or October, and thus it is evident that the insect hibernates in the adult stage.

SEASONAL HISTORY

The life history of *Hypena humuli* may vary greatly, depending on weather conditions and the date of emergence of the moths from hibernation. The following is the normal life cycle. Eggs are laid about the middle of May and hatch in about two weeks. The larvae become full-grown by July 1, the larval stage lasting about one month. The pupal stage covers about thirteen days and adults emerge about the middle of July. Eggs of the second brood are laid in from one to two weeks, and these hatch the first week of August. The larvae are full-grown at hop-picking time, early in September, when they pupate. Moths come out during the latter half of September and seek hibernating quarters.

NATURAL ENEMIES

Nymphs of *Paracalocoris hawleyi* and adults of *Reduviolus subcoleopratus* Kirby are both occasionally predacious on the larvae of *Hypena humuli*.

Masicera rutila Meign.,⁵ a tachinid fly, was bred from a snout-moth larva in 1914. A larva taken into the laboratory on July 6 started to spin its cocoon on July 11 and the parasites emerged from the cocoon on August 4. In the summer of 1915, the parasite *M. eufitchiae* Towns.⁵ also was bred from a snout-moth larva.

Howard (1897) reports *Exorista hypenae* also as a parasite on the larva of *Hypena humuli*.

CONTROL

During the past three years no opportunity occurred to test control measures against the hop snout-moth. It has been reported that powdered arsenate of lead mixed with the sulfur used for the hop mildew, in a ratio of 1 to 10, has been found effective. If spraying is practiced for the hop aphid, the addition of arsenate of lead to the nicotine sulfate spray should prove a satisfactory control measure against the hop snout-moth.

⁵ Determined by O. A. Johannsen.

THE FILAMENTED LOOPER

(Nematocampa limbata Haworth)

The larva of the filamented looper has been found as a leaf-eating pest of the hop in large numbers near Sangerfield, New York. It is not restricted entirely to this region, however, a few specimens having been found in some hopyards thirty miles away. The species is a general feeder, having been reported from currant, birch, stonecrop, plum, apple, crab apple, oak, and hazel, and on strawberry under the name *strawberry looper* (Packard, 1876, and Luggur, 1898). It may have come to the hop in the form of eggs on the cedar hop poles; but more probably it has migrated from other plants, as many of its known hosts occur in the region. It is widely distributed in the eastern part of this continent, being reported from Canada, New England, Minnesota, Georgia, and Illinois (French, 1878, and Luggur, 1898). While it is not of great economic importance at the present time, its numbers are increasing and it may become a serious pest.

DESCRIPTION

The egg

The egg of the filamented looper is about 0.4 millimeter in length, 0.2 millimeter wide, and 0.1 millimeter high, or of the horizontal type. The color is pale green when the egg is freshly laid, turning in from twenty-four to forty-eight hours to a dull tomato red. The egg is oblong, truncate and slightly depressed at the micropyle end and rounded at the opposite end. The surface bears faint, hexagonal reticulations.

The larva

The larva passes thru four stages, which may be described as follows:

First stage.—Length (one day) 1 mm.; alternating tomato red and faint greenish white crossbands; head of a brown tint. One pair of prolegs and anal prolegs.

Second stage.—Length 4 mm. (average of five specimens); abdominal red bands more distinct; anal end suffused with red. Small tubercles appearing for the first time on second and third abdominal segments.

Third stage.—Length 9 mm. (average of five specimens); filaments at least equal to diameter of body in length; markings similar, but a variation occurring as in fourth stage.

Fourth stage.—(Detailed description of full-grown larva.) Length 18-20 mm.; color variable; general color gray, but some forms having a prominent tinge or oblique markings of shades of green, yellow, or brown. Body cylindrical. Head mottled, large, full on each

side and flattened in front. First abdominal segment bearing a sub-acute tubercle; second and third segments having a pair of long, flexible filaments of the same color as the body; those of the second segment, which are white-tipped, reaching the head when extended forward; those of the third segment about two-thirds as long as those of second segment; two small tubercles caudad of each of these appendages, and back of those of the first

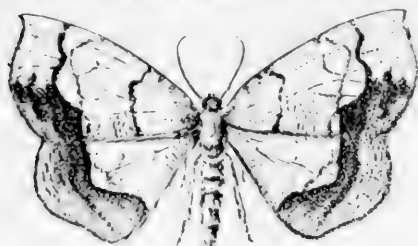


FIG. 49. ADULT MALE OF FILAMENTED LOOPER. $\times 2\frac{1}{2}$

two abdominal segments two light yellow spots; median dark line running from the head to the first pair of filaments in dark forms; eighth abdominal segment bearing a pair of medianly joined tubercles, appearing from the side as a fleshy hump; just caudad of the hump and running to the end of the anal shield, a dark area bordered by yellow; a lateral lighter area present above and between the two pairs of prolegs.

The pupa

The pupa is from 10 to 11 millimeters long. It is gray or pale yellow in color, and is mottled except for the membrane between the abdominal segments. The cremaster consists of two pairs of terminal outwardly curving hooks, one large and one small, and a third pair of hooks just before the apex.



FIG. 50. ADULT FEMALE OF FILAMENTED LOOPER. $\times 3$

incurved at points where inner is excurved and in some cases meeting it at those points; outer third of wing brown on inner half in male and everywhere but at apex in female; fringes brown. Hind wing similar, without t.a. line and with brown area more extensive; veins more or less brown, especially in female. Spread 19-25 mm.

LIFE HISTORY AND HABITS

The egg

The eggs of the filamented looper are attached by a secretion under the edge of projecting bark, or tucked in cracks of the hop poles, and

The adult
The adult (figs. 49 and 50) is described as follows by Dr. W. T. M. Forbes:

Male straw yellow, female cream white. Fore wing with three even brown lines; t.a. line excurved, especially over cell; inner t.p. line excurved beyond cell and slightly at fold, outer t.p.

are found singly, a few in a place, or in irregular masses (figs. 51 and 52). The writer has found fifty or more eggs on a cedar hop pole by removing



FIG. 51. EGGS OF FILAMENTED LOOPER UNDER PROJECTING EDGE OF BARK OF A CEDAR HOP POLE. $\times 8$

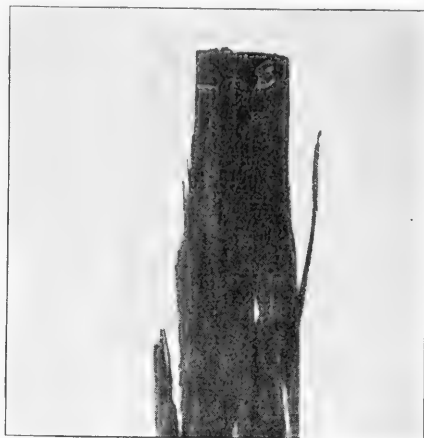


FIG. 52. EGGS OF FILAMENTED LOOPER ON A SLIVER OF A CEDAR HOP POLE. $\times 5$

the bark and inspecting the crevices. Overwintering eggs are laid in August, and hatch from the middle of May until late in June of the following year; the egg stage is therefore about ten months. Two females under observation laid eggs as indicated in table 14:

TABLE 14. DATA ON EGG LAYING BY TWO MOTHS, 1915

Specimen	Date when female emerged	Date when first eggs were laid	Number of eggs found on August 28	Date preceding which moths died
1.....	August 15	August 23	25	September 8
2.....	August 18	August 25	16	September 8

The larva

The larva moves with a looping motion (fig. 53), and when disturbed it assumes an erect attitude and projects its filaments to the limit. It

may also drop by a thread and hang in mid-air; sixty suspended larvae have been counted on one hill after the pole had been shaken. The larva



FIG. 53. LARVA OF FILAMENTED LOOPER. $\times 2\frac{1}{2}$

feeds oftener on the margin of the leaf than in the central part. The veins of a leaf are often eaten thru in such a way that the leaf dies at that point and a dead crumpled area on the margin remains. A larva, perhaps for protection, often assumes a position resembling this dead part of the leaf. Full-grown larvae have been found from June 25 until August 18. Six specimens were bred in petri dishes in the summer of 1915, as indicated in table 15.

The pupa

The change to the pupal stage takes place in the cracks of hop poles, in leaves curled and fastened with a few strands of silk, or when the larva is attached by silk flat against an uncurled leaf. Often the pupa is attached by a few strands of silk and hangs free from a leaf or a vine (fig. 54). In

TABLE 15. DATES OF TRANSFORMATION AND LENGTH OF STAGES, 1915

Specimen	Date when egg was taken	Date of hatching	Dates of molts	Date when cocoon was spun	Date when pupal stage began	Date when adult stage began	Number of days from egg to adult
1.....	.....	June 28	July 6, 9, 13	.....	July 23	August 7	40
2.....	May 6	June 6	.....	.....	July 16	July 29	53
3.....	May 6	July 16	July 21, 25, August 1	August 11	August 14	August 28	43
1.....	May 12	July 20	July 24, 29, August 4	August 11	August 13	August 27	38
5.....	May 21	July 7	.....	.....	August 2	August 15	39
6.....	May 21	July 5	.....	.....	August 3	August 15	41

Average—Larval stage, 28.8 days; pupal stage, 13.5 days; egg to adult, 42.3 days.

many cases small pieces of dead leaves are curled around the pupa. Pupae have been found from June 27 until August 28.

The adult

The brightly colored moths are common in August in the hopyards. They rest flat on the ground and on the lower leaves, with their wings half spread. The sexes are about equal in number.

SEASONAL HISTORY

The life history of *Nematocampa limbata* varies greatly, depending on the time of hatching of the eggs. A typical life history is as follows:

The eggs, which are laid on hop poles in the latter part of August, hatch the last of the following June. The larvae become full-grown the last of July, and enter a pupal stage which covers two weeks. Adults appear the middle of August and begin to lay eggs in about one week. There is one generation a year.

CONTROL

The control measure suggested for the hop snout-moth should hold the filamented looper in check also. On July 17, 1915, several infested hills were dusted with powdered arsenate of lead and sulfur in a ratio of 1 to 10. When the hills were examined later some live larvae were found. Since rain followed soon after the application, however, the test was not a fair one.



FIG. 54. PUPA OF FILAMENTED LOOPER. $\times 4$

THE HOP APHIS

(Phorodon humuli Schrank)

The hop aphis, *Phorodon humuli* (figs. 55 and 56), is a pest wherever hops are grown. It has been known in New York State since 1863 at least (Parker, 1913), and in some years has caused an almost total loss of the crop. As the insect has been extensively studied on the Pacific coast, the writer has limited his work on the species to observations on its seasonal history and habits in New York State, and to the application of some control measures under New York conditions.

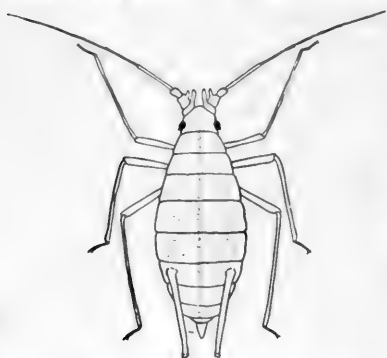


FIG. 55. WINGLESS VIVIPAROUS FEMALE OF HOP APHIS. ENLARGED

SEASONAL HISTORY

In the eastern United States the hop aphis has been found to winter only in the egg stage on plum. Clarke (1904) reports that in California the aphides winter on hop roots. In order to obtain some evidence on this point for New York, the writer removed the dirt from three hills, placed vines covered with the insects around the hop roots, and then covered the hills. On examination the following



FIG. 56. WINGED VIVIPAROUS FEMALE OF HOP APHIS. ENLARGED

spring, no signs of live aphides or of their eggs could be found in these hills. Additional evidence is furnished by the fact that migratory aphides have always appeared on the hop before the wingless forms.

Altho Riley (Riley and Alwood, 1889) reported the third generation as the one that produces winged forms in New York, it is probable that some winged forms are produced in the second generation. On May 21, 1913, full-grown lice and recent offspring were found on a plum tree near Sangerfield. On most of the leaves there was one full-grown louse, but on one leaf there were five.

Some of the young of these forms had wing pads on the 4th of June. If those first found were of the first generation, the second generation produces winged forms, the same as in the Pacific hop region. Some insects of the third generation also are winged. In fact, the writer has found winged forms being produced on a plum tree under observation thru July and August, but, for unknown reasons, after the June migration there have been but few winged forms on the hop. The height of the return migration occurs during hop picking, about the first of September.

On the hop the winged insects are found on the underside of the topmost leaves (fig. 57), there being from one to twenty or more to a leaf. The wingless descendants from these also live on the underside of the tender foliage. In August, when the lice are numerous, full-grown forms are occasionally found along the veins on the upper side of the leaves. When the young hops are formed, lice migrate to them in



FIG. 57. WINGED VIVIPAROUS FEMALE OF HOP APHIS ON A LEAF. ENLARGED

large numbers. The writer has noted young lice in hop cones when the leaves were comparatively free from the insects.

Two species of ants have been found associated with the hop aphid—a large species, *Formica fusca* var. *subsericea* Say; and a small form, *Prenolepis imparis* Say.⁶



FIG. 58. ABOVE, HOPS INJURED BY THE HOP APHIS; BELOW, HEALTHY HOPS. ABOUT ONE-HALF NATURAL SIZE

NATURE OF THE INJURY

The injury to the hop caused by *Phorodon humuli* is of two kinds: (1) the weakening of the vines and the stunting of the hop cones due to the constant removal of sap; and (2) the coating of the hops with honeydew in which a fungus, *Cladosporium*, grows.

The feeding of the aphides on the leaves and the vines so weakens the plant that it is common to find hills in which the vines have not climbed above the string. The vines are dwarfed and the hop cones are small, with sickly, scraggly bracts (fig. 58). This condition is found when the aphides attack the hill in numbers early in the season.

When the lice become numerous (fig. 59) the leaves glisten with the honeydew which they excrete. The entire surface of the vines and the leaves is coated with this excretion. When the lice enter the cones the bracts also are covered. The greatest damage is caused when the lice enter the full-grown hops just before picking time. They coat the hops with the honeydew, causing

⁶ Both species determined by W. M. Wheeler.

the bracts to lose their crispness and making them stick together when pressed between the fingers.

The fungus *Cladosporium* grows in the honeydew and gives the hop a soot-covered appearance. This greatly injures the quality and makes the hops unsalable. Among hop growers it is spoken of as *black mold*. Many yards in New York were injured in this manner in 1915 and the hops were not picked, while hops from some yards that were picked are



FIG. 59. WINGLESS HOP APHIDES ON A HOP LEAF. \times ABOUT 5

still unsold. The lice are much more numerous in warm, moist seasons. In 1915 the rainfall records taken showed 5.49 inches during June, 7.64 inches during July, and 9.28 inches during August. This is much above the normal for these months. A wet spring followed by a long, dry period is not so serious as continued rains near harvesting time. Under the latter condition great loss may result in a few weeks, owing to the increase of the lice, the great production of honeydew, and the growth of the black mold.

NATURAL ENEMIES

Predatory enemies

The following predatory insects have been collected feeding on the hop aphids:

Coleoptera	Family
<i>Adalia bipunctata</i> Linn.	Coccinellidae
<i>Hippodamia convergens</i> Guer. (lady beetle, figs. 60 and 61)	Coccinellidae
<i>Coccinella trifasciata</i> Linn.	Coccinellidae
<i>Coccinella 9-notata</i> Herbst.	Coccinellidae
<i>Coccinella sanguinea</i> Linn.	Coccinellidae
<i>Hippodamia parenthesis</i> Say.	Coccinellidae
<i>Anatis 15-punctata</i> Oliv.	Coccinellidae
Neuroptera	
<i>Chrysopa oculata</i> Say ⁷ (aphis lion, fig. 62)	Chrysopidae
<i>Hemerobius stigmaterus</i> Fitch ⁷	Hemerobiidae
Diptera	
<i>Syrphus americanus</i> Wiedemann ⁸	Syrphidae
<i>Allograpta obliqua</i> Say ⁸	Syrphidae



FIG. 60. LARVA OF LADY BEETLE ON A HOP LEAF.
× ABOUT 2

Parasites

One parasite has been bred from the hop aphids — *Praon* sp.,⁹ of the order Hymenoptera, family Braconidae.

SPRAYING AND CONTROL
EXPERIMENTS

The spraying operations for control of the hop aphids undertaken by growers during 1915 were observed by the writer. These are here described, and some original data on spraying and dusting are given.

⁷ Determined by R. C. Smith.

⁸ Determined by O. A. Johannsen.

⁹ Determined by A. B. Gahan, thru the kindness of Dr. L. O. Howard.

The first spraying of the season was done on the Louie farm, at Schuyler Lake. The material used was nicotine sulfate (Black-leaf-40) in a solution of 1 gallon to 2000 gallons of water, with whale-oil soap added, 4 pounds to 100 gallons. A Friend pony outfit (fig. 63); with three leads of hose, was used. Two men, with 6-foot poles, 30°-angle nozzles, and 15 feet of hose, covered two rows each, and the third man, going



FIG. 61. EGGS OF LADY BEETLE ON A HOP LEAF. ENLARGED

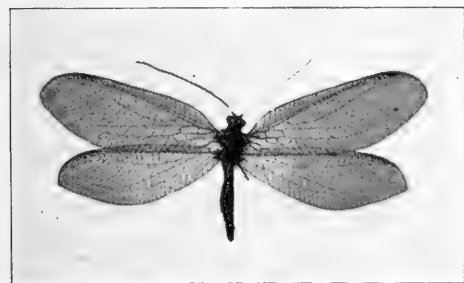


FIG. 62. APHIS LION, THE LARVA OF WHICH IS PREDACIOUS ON THE HOP APHIS. ENLARGED

(Photograph by H. H. Knight)

behind, covered the high arms and the tops of the poles. Calyx nozzles of the Vermorel type, throwing more than the usual quantity of material, were used. The tank had a capacity of 150 gallons, and with a 1½-horse-power engine a pressure of over 150 pounds was maintained. The cost for spraying two acres a day was as follows: four men, \$8; one horse, \$1; 800 gallons of spray material, \$6; total, \$15 for two acres, or \$7.50 an acre. Hops of a fine quality were produced.

Under the direction of F. M. Blodgett, about ten hopyards were sprayed. In one yard, near Waterville, a pressure of 165 pounds was maintained and 600 or more gallons of spray material were used to the acre. In all cases nicotine sulfate (1-2000) and whale-oil soap (4-100) were used. During these operations the writer picked sprayed leaves and made counts

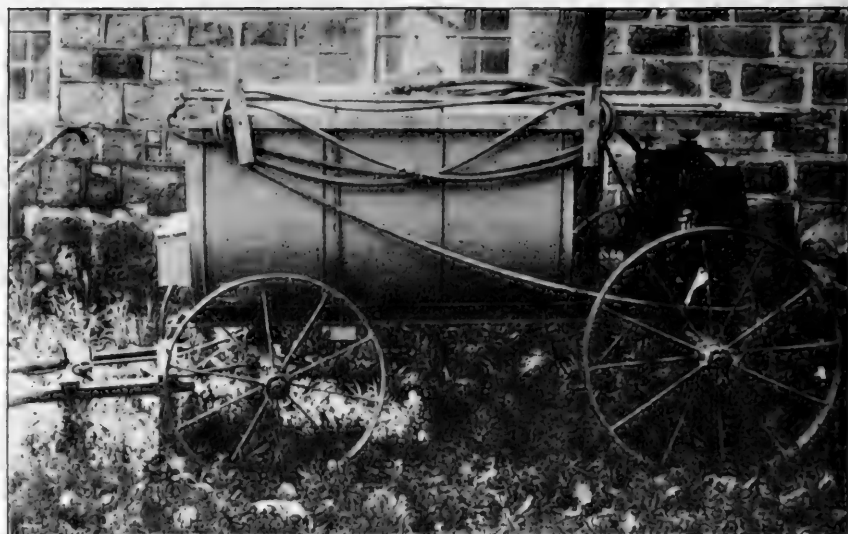


FIG. 63. SPRAYER USED ON THE LOUIE FARM — A COMMON TYPE

to test the effectiveness of the spray. The results of these counts are given in table 16:

TABLE 16. RESULTS OF SPRAYING EXPERIMENTS WITH BLACK-LEAF-40, 1915

Yard	Date of spraying	Date of count	Number of lice found	Number dead	Per cent of control	Number of leaves used	Remarks
Hatch	July 27	July 28	830	821	98.9	20	All lice counted
Hatch	August 18	August 19	106	100	94.3	12	Only full-grown lice counted
Hatch	August 19	August 20	356	352	98.9	12	Only full-grown lice counted
Hewett	August 31	September 2	721	698	96.8	20	All lice counted

Sulfur is used by growers to control the hop mildew, and so the writer tried combinations of sulfur with nicotine sulfate, using different stickers, to see its effect on the lice, paying no attention to the control of the hop mildew. The results are given in table 17:

TABLE 17. RESULTS OF EXPERIMENTS TO TEST BLACK-LEAF-40 WITH SULFUR IN VARIOUS FORMS, 1915

(Only full-grown lice were counted. B.L.40 = Black-leaf-40, 1-2000; L.S. = lime-sulfur, 1-40; Sp. = soap, 4-100; S = sulfur)

Material used	Date of spraying	Date of first count	Number of leaves used	Number of lice found	Number alive	Per cent of control	Date of second count	Number of leaves used	Number of lice alive
B. L. 40, Sp., S	July 16	July 17	12	828	11	98.7	July 24	12	4
B. L. 40, L. S.	July 16	July 17	12	360	16	95.5	July 24	12	30
B. L. 40, L. S., Sp.	July 16	July 17	12	574	3	99.5	July 24	12	4
B. L. 40, Sp.	July 17	July 20	12	77	2	97.4	July 24	12	1

Lime-sulfur leaves a smeary coating and should not be used just before the hops are to be picked. None of the sprays tested injured the hops.

There has been much demand among growers for a louse-killing material that can be applied in a dust form with the sulfur used for the hop mildew. With this in view an experiment was carried on in two parts. In one (W, table 18) the hills were sprayed with water and the material was dusted on; in the other (D) the material was applied to the dry leaves. Both the upper and the under sides of the leaves were well covered in each case. The results of these experiments are given in table 18:

TABLE 18. RESULTS OF DUSTING EXPERIMENTS, 1915

(Ten leaves of each kind were examined, and only adult lice were counted)

Material used	Date of application	Date of count	Number of lice found	Number dead.	Number alive	Per cent of control
Tobacco dust.....(W)	August 6	August 10	249	12	237	4.8
(D)	August 6	August 10	125	4	121	3.2
Tobacco dust and sulfur, 1-1.....(W)	August 6	August 10	243	6	237	2.5
(D)	August 6	August 10	86	0	86	0.0
Tobacco dust and flour, 1-1.....(W)	August 6	August 10	138	57	81	41.3
(D)	August 6	August 10	116	5	111	4.3
Tobacco dust and soap, 3-1.....(W)	August 6	August 10	128	80	48	62.5
(D)	August 6	August 10	78	7	71	9.0
Tobacco dust, sulfur, and soap, 2-3-1(W)	August 6	August 10	126	113	13	89.7
(D)	August 6	August 10	49	3	46	6.1

It is evident that dusting was not effective. The tobacco dust, which was used as the killing agent, was useless even when the leaves were wet. A few aphides were stuck to the leaves by the flour when wet. The powdered soap, when wet, was efficient, but inasmuch as this soap costs 22 cents a pound it cannot be considered practicable. Only a driving rain of long duration could wet the underside of the leaves, and with such a rain there would be a tendency for the lice to be washed off and a spray applied would be of little use.

If the lice on the plum are killed, the infestation will be cut down. This cannot be considered as a sure control, because scrubby plum trees along fence rows are prolific breeding centers. The writer found many winged lice in one corner of a hopyard. In searching for the source he found a small plum tree, less than three feet high and almost concealed by grass, completely covered with the pests.

Lice are apparently carried long distances by the wind. Winged forms have been found in large numbers in yards where the owner declared there were no plum trees within half a mile. A thoro search by the writer did not disclose the source of the infestation. It is possible that some other host may exist, but none has been found, even tho many kinds of trees and bushes have been examined for lice of this species.

Recommendation

The following practice is recommended for control of the hop aphid:

Spray the last week of June or the first week of July with nicotine sulfate (1-2000, or $\frac{3}{8}$ pint to 100 gallons) and soap (4-100). Use a one-horse sprayer with a 150-gallon tank and three leads of hose. Use two 6-foot poles with 30°-angle nozzles and 15 feet of hose, and one longer pole without the angle and with 30 feet of hose. Let each of the men with the short poles cover the lower vines and arms of two rows, and let the man behind, with the long pole, cover thoroly the higher vines and arms (fig. 64). A Vermorel-type nozzle throwing a coarse spray is efficient, but a nozzle producing a mist spray is recommended on the Pacific coast. The soap should be melted in quantity; a large iron kettle is convenient for this purpose. If the yard is distant from the water supply, a filling wagon is necessary.

It is important to hit all lice. Those on the higher, tenderer leaves, where the winged forms collect and where the migration to the hop cones takes place, must be killed. Late spraying is ineffective, as some lice cannot be reached because of the growth of the arms and because some will have migrated into the burs and the hops. If all winged lice are killed early in the season, there will be none to reproduce later.



FIG. 64. SPRAYING HOPS WITH A POWER SPRAYER

(Photograph by C. R. Crosby)

Because of this pest, New York State in the past has lost hops which have cost thousands of dollars to raise. Spraying should be considered as crop insurance. While it will not result in saving a crop every year, it will improve the quality of the product and raise the price when the average quality is low. The history of the past few years proves that hop dealers want hops of a good quality, and that such hops usually sell readily and at an advantageous price.

THE RED SPIDER, OR SPIDER MITE

(Tetranychus telarius Linnaeus)

The red spider occasionally appears in the hopyards of New York, but has never caused any serious damage here such as it has on the Pacific coast. With the shorter growing season and the cold winters, it is not likely that it will become a serious pest.

The mites were observed on weeds and hop poles on May 6, 1915, and it is probable that they hibernate mainly as adults in cracks of the poles or on dead weeds around the yards. The presence of the mite may be detected by small, light yellow spots at the base of a leaf between the main veins. If the underside of such a leaf is examined, silken webs will be found and beneath these the mites usually rest. Later the leaves turn yellow and a few drop off. The lower leaves are first attacked, and as these leaves are killed the mites move upward and some enter the hops. A few mites were found in the hops of one yard in the dry summer of 1913.

CONTROL

It has never been necessary to adopt control measures against the red spider in New York hopyards. In 1913 a few hills were sprayed with flour paste (8-100), and others with lime-sulfur (1-80) and flour paste (4-100), as recommended by Parker (1913, a and b) in consequence of his work on the Pacific coast. The action of both materials was satisfactory, but, as neither spray kills the eggs and since only one application was made, mites were present a few weeks later. Not all the mites were killed, as the mist spray which was used did not always penetrate the webs to the mites beneath. If desirable, flour paste or lime-sulfur may be applied in combination with the Black-leaf-40 used for control of the hop aphids. Black-leaf-40 with soot will kill many of the mites, and if used at a high pressure it might give control.

THE HOP MERCHANTS

(Polygonia interrogationis Fabricius and P. comma Harris)

The chrysalides of the two well-known butterflies *Polygonia interrogationis* and *P. comma* are called *hop merchants*, and are familiar to growers

because of a superstition that is connected with them. If the spots on the chrysalis (fig. 65) are golden, it is supposed that the hops will be of good quality and will bring a high price; but if the spots have a silver tint, the opposite is to be expected. Growers do not as a rule connect the spiny larva (figs. 66 and 67) or the brightly colored butterfly (fig. 68) of the two species with the hop merchant, and yet these insects have been of such popular interest to the student of nature that their life histories, food plants, and dimorphism have been understood for many years. There are usually two broods a year, and the chrysalides of



FIG. 65. CHRYSALIS OF HOP MERCHANT.
ABOUT NATURAL SIZE
Polygonia interrogationis

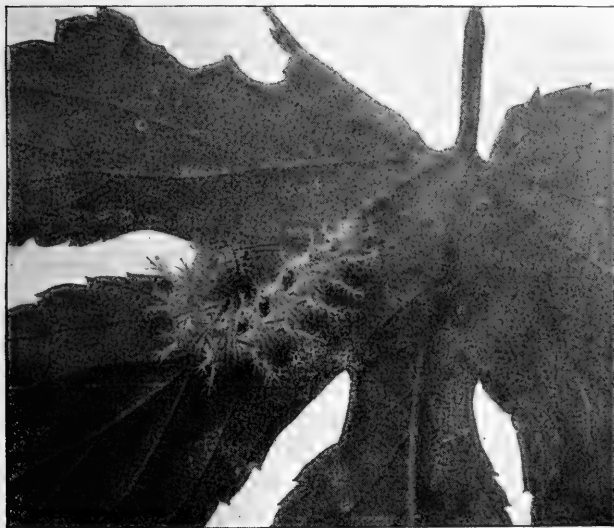


FIG. 66. LARVA OF HOP MERCHANT. ABOUT NATURAL SIZE
Polygonia interrogationis

the second brood, often found at hop-picking time, are of great interest to hop pickers. The insects are not of economic importance, for aside from a few leaves eaten by the larvae they do no harm.

Many of the larvae of both species are parasitized by a bright green chalcid fly (*Pteromalus vanessae* Harris).¹⁰

The writer placed caterpillars of *Polygonia interrogationis* in a cage in July, and when examined on August 24 many of the chrysalides had taken on a distinctly yellow color and

¹⁰ Determined by A. B. Gahan, thru the kindness of Dr. L. O. Howard.

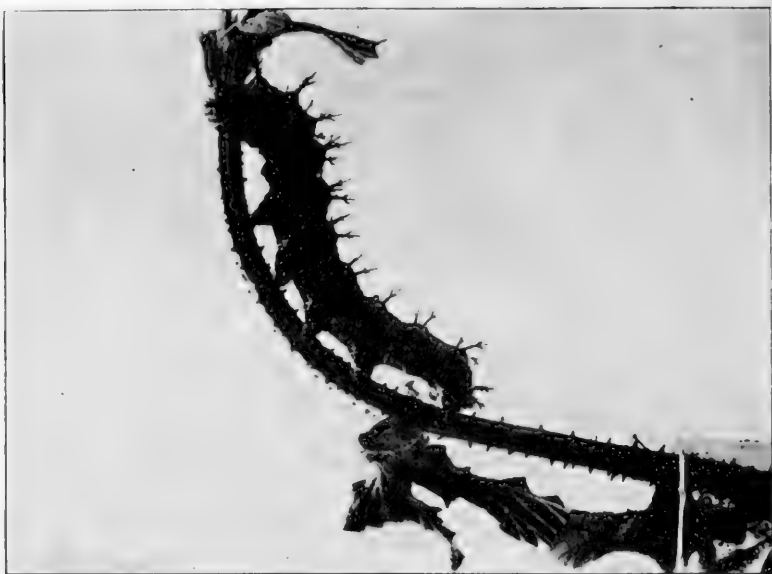


FIG. 67. LARVA OF HOP MERCHANT. NATURAL SIZE
Polygonia interrogationis



FIG. 68. ADULT OF HOP MERCHANT. SLIGHTLY REDUCED
Polygonia comma
(Photograph by H. H. Knight)

parasites were found to be emerging thru holes in their sides. One chrysalis contained 12 full-grown chalcids. Howard (1897) believes the insects are held in check by this means.

LEAF HOPPERS

(*Empoasca flavescens* Fabricius and *E. flavescens birdii* Goding)

Leaf hoppers (*Empoasca flavescens* Fab. and the variety *E. flavescens birdii* Goding) are often present in large numbers on the hop plant. Twenty or more may be found on the underside of one of the lower leaves, but the insects are never found on the burs or the hops. The insect probably winters as an adult in New York, since specimens have been found near yards and on hop poles during the first part of May of each year. In Illinois adults taken on December 16 emerged from hibernation on April 20 (Forbes, 1900). In 1915 nymphs of the first brood began to appear on the hop the middle of June; these transformed to adults about the middle of July, and from this time forward all stages could be found on the leaves. A second brood occurs every season, and in dry seasons there is probably a partial third brood. The insects seem to be more numerous in dry seasons. In 1913, when the hop aphid was scarce, there was a general outbreak of leaf hoppers.

When leaf hoppers are numerous the leaves lack vitality and turn yellow. In June, 1915, in one badly infested yard the leaves were much curled. At that time the writer attributed the injury to leaf hoppers, but as this yard was frostbitten early in the season it is possible that this conclusion was incorrect. Accordingly an experiment was undertaken to test the point. Several hundred leaf hoppers were placed in paraffined bags which were tied on the arms of a hop vine in a yard nearly free from the insects. On July 14, over a month later, when the bags were examined, the leaf hoppers were all dead and the leaves in one bag showed curling. In the other bags there was no curling and the leaves appeared much as in the check bags.

Empoasca flavescens is a general feeder. The writer has collected specimens on plum in the fall, and the variety *birdii* has been previously reported on beans, weeds, walnuts, and apple trees (Forbes, 1900); in Illinois it often causes damage to the last-named host. *E. flavescens birdii* has a smoky band across the hemelytra, which is wanting in *E. flavescens*.

The writer has taken both forms in the same hopyard. According to Forbes (1900) the species is widespread; it has been reported from New York to the District of Columbia, and from California and Mexico.

CONTROL

While spraying for the red spider it was observed that flour paste often sticks the nymphs of leaf hoppers to the leaves. The usual aphid spray of nicotine sulfate and soap destroys them readily.

THE MILLIPEDE

(*Julus caeruleocinctus* Wood)

A species of millipede (*Julus caeruleocinctus*,¹¹ fig. 69) seems to be always present in large numbers in hopyards. Several hundred specimens, in all stages of development, may often be taken from a single hill. They are the most plentiful where there is decaying matter, and are especially numerous in dead and dying hop roots.



FIG. 69. A MILLIPEDE FOUND IN HOP-YARDS. $\times 2\frac{1}{2}$

No damage is caused by the millipede after the hop vines have become hardened. In order to test this, a cage was sunk around a hop hill and several hundred millipedes were placed in it. No damage to the vines resulted. In May, when the succulent hops are just

coming up, shallow areas are occasionally eaten in the stems. These soon grow over without seriously retarding the growth of the vines.

It was observed in the experiments for control of the hop grub, that carbon disulfide applied in large quantities often proved fatal to millipedes.

THE LEAF MINER

(*Agromyza* sp.)

The larva of a dipterous leaf miner (*Agromyza* sp.) is often found working in the lower leaves of the hop during May and June. On June

¹¹ Determined by R. V. Chamberlin.

7, 1915, the serpentine mines caused by the insects (fig. 70) were very numerous at Waterville. Specimens of the leaf miner were bred and



FIG. 70. MINE OF A DIPTEROUS LARVA IN A HOP LEAF. SLIGHTLY ENLARGED

identified for the writer by S. W. Frost. The insect belongs to the Agromyzidae and is thought to be a new species.

FLEA BEETLES

(*Psylliodes punctulata* Melsh., and others)

Flea beetles are occasionally found on the hop in New York, but they have never been numerous enough to cause serious damage. The writer has found from five to ten on a hill, and a lower leaf here and there will show the work of the insects in the form of small holes between the veins. In the hop sections of the Pacific coast, the hop flea beetle (*Psylliodes punctulata*) has caused great damage and has been a difficult pest to control (Parker, 1909). The following species have been taken by the writer on the hop plant: *Psylliodes punctulata* Melsh., the punctured flea beetle (the hop flea beetle of the Pacific coast); *Epitrix cucumeris*

Harr., the potato flea beetle; *Psylliodes convexior* Lec.; *Systema frontalis* Fab., the red-headed flea beetle.

LEAF ROLLERS

(*Archips rosaceana* Harris and *A. argyrospila* Walker)

The oblique-banded leaf roller (*Archips rosaceana*) is occasionally found on the hop. The white egg masses are found on the upper side of the leaf, and are easily mistaken for a healthy spot of the hop mildew. An egg mass taken to the laboratory on July 15, 1915, hatched on July 18. Two of the larvae were separated and supplied with food. One pupated on August 15 and emerged on September 5; the other pupated on August 17 and emerged on September 6. From other larvae taken to the laboratory, two parasites (*Meteorus* sp. and *Itopectis conquisitor* Say¹²) were reared. The newly hatched larvae destroy a few leaves but do little real damage.

A larva of the fruit-tree leaf roller (*Archips argyrospila*) was found on the hop on May 6, 1915. At that time it was feeding on the tender tissues of the tip, and had produced a muffle head similar to that caused by the larva of *Gortyna immanis*.

MISCELLANEOUS INSECTS ON HOP

In the following list are given a number of additional species of insects that are found on hops, together with data regarding them:

Species	Stages	Parts of plant infested	Time of appearance	Numbers	Injury caused
<i>Lygus pratensis</i> Linn.	Nymph, adult.	Lower leaves.	July-August.	Numerous.	None
<i>Lygus inivitus</i> Say.	Nymph, adult.	Lower leaves.	July-August.	Numerous.	None
<i>Phytocoris</i> sp.	Adult.	Lower leaves.	.....	Few.	None
<i>Diabrotica 12-punctata</i> Fab.	Adult.	Lower leaves.	.....	Few.	None
<i>Corymbites cylindriciformis</i> Herbst	Adult.	Hop heads, leaves	May.	Few.	Slight
<i>Lac. nosterna</i> sp.	Larva.	Roots.	All seasons.	Few.	None
<i>Tel. phorus tuberculatus</i> Lec.	Adult.	Leaves.	August-September.	Few.	None
<i>Tel. phorus bilineatus</i> Say.	Adult.	Leaves.	August-September.	Few.	None
<i>Podabrus rugosulus</i> Lec.	Adult.	Leaves.	August-September.	Few.	None
<i>Mamestra picta</i> Harr.	Larva.	Leaves.	June.	Few.	None
<i>Peridroma margaritosa</i> Haw	Larva.	Leaves.	June.	Few.	None
<i>Erannia tiliaria</i> Harr.	Larva.	Leaves.	May-June.	Few.	None
<i>Lycia cognataria</i> Guen.	Larva.	Leaves.	June.	Few.	None
<i>Automeris io</i> Fab.	Larva.	Leaves.	August-September.	Few.	None
<i>Trapaea luna</i> Linn.	Larva.	Leaves.	August-September.	Few.	None
<i>Notophus antiqua</i> Linn.	Larva.	Leaves.	August-September.	Few.	None
<i>Hemerocampa leucostigma</i> Smith & Abbott	Larva.	Leaves.	August-September.	Few.	None

¹² Determined by A. B. Gahan, thru the kindness of Dr. L. O. Howard.

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Detailed description of adult, which is mentioned as rare; illustration of adult.

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The first record that the hop grub is the species *immanis*. The egg is unknown, but the author thinks it is probably laid on the head of the hop, altho some eggs may be laid on the roots. Larvae found in May. Larva feeds on the head of the hop and bores down to the second joint, leaves the head, enters the vine, and later works externally. Pupa stage of one month begins in July or the first of August; no trace of cocoon or pupal cell. Author assumes hibernation of adult. Recommends control according to Dodge. Article illustrated.

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FLINT, DANIEL. The enemies of the hop plant. Pacific rural press, March 1882, p. 196. 1882.

A popular article concerning an unknown insect which bores in hop vines and also in hop poles. [This has been reported by some writers to be *Gortyna immanis*, but is probably a beetle larva.]

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A systematic paper. The type of *Hydroecia* is given as *nicitans*, and the type of *Gortyna* as *micacea*. The species *immanis* is in *Gortyna*.

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humuli.] Larva on hatching enters head of hop and causes head to hang down, forming a muffle head. When larva is one-half inch long it leaves head and enters vine, which becomes hard and hollow as flow of sap stops. About June 21 larva leaves head and feeds on outside of vine, nearly or entirely severing it. Pupation occurs about the middle of July in a rude cell; the pupae hibernate as a rule, but a few adults emerge in the fall. Control: Cultivate skunks; destroy pupae in spring; pinch heads of hops; expose roots about one week in June and add a mixture of coal and wood ashes or ammoniated phosphate, then hill high, and vines stimulated by fertilizer will send out rootlets to get food. *Calosoma calidum* is predacious on young grubs. *Hydroecia obliqua* considered a Western variation of *H. immanis*.

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